SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1917.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1917.

GENERAL PHYSICS.

1067. *New Form of Balance.* (Engineer, 124. p. 192, Aug. 31, 1917.)—Describes, with two photographs, a type of balance for assaying and chemical analysis work, made by Heussler, of Salt Lake City, Utah. One of the special features of the balance is the arrangement whereby the smaller weights, from 100 to 1 mgm., are applied to the balance in a more or less mechanical manner. The individual weights provided are 1, 2, 3, 5, 10, 20, 30, 50, and 100 mgm., giving any number up to 221 mgm. The weight-pan hanger carries near its top a bridge-piece provided with nine countersunk holes. A pillar at the back of the case carries nine corresponding levers, each of which is provided with a rod having a conical tip. On these conical tips are supported the nine weights, which take the form of perforated metal discs. On lowering any one lever the corresponding rod and cone pass clear through the hole in the bridge-piece, leaving the weight behind in the countersunk hole. On raising the lever again the weight is removed. Thus the application and removal of the small weights can be effected, even by an unskilled person, in a speedy and delicate manner. The beam has been made as light as possible, and it is provided with a horizontal bar for the usual rider. The rider scale is attached to the tube carrying the usual rod with arm used for moving the rider to any desired position along the beam. A. W.

1068. *Microscopic Indicator on Measuring Machines.* **F. Göpel.** (Zeits. Instrumentenk. 37. pp. 142-145, July, 1917. From the Physikal.-Techn. Reichsanstalt.)—The "anvil" end of the measuring machine is controlled as usual by a spring. On being pressed back, when a gauge is being measured, the far end of the anvil bears against a sensitive lever by which any movement is multiplied 30- or 40-fold. The far end of the lever (*i.e.* the end which has the multiplied motion) carries an illuminated index mark, which is viewed by a low-power microscope. The unit of measurement is 0·0001 mm. P. E. S.

1069. *Combined Stresses.* **A. L. Jenkins.** (Am. Soc. Mech. Eng., J. 39. pp. 694–699, Aug., 1917.)—A consideration of the relative merits of the max. shear stress and other possible hypotheses for calculating the ultimate strength of a material subjected to combined stresses. It is concluded that the hypothesis applicable to a particular material depends on the relative performances of that material in tension, compression, and shear. Two systems of stresses may be used in the calculation, viz. (i) the apparent stresses calculated by the ordinary methods of statics (i.e. by dividing the load by the area), and (ii) the equivalent stresses found by assuming that stress is that property of a material which resists deformation or strain, so that its intensity is measured by the product E*s*, where E is the modulus of elasticity, and *s* the unit strain (or deformation produced in a unit length). It is concluded that the equivalent stresses are a refinement over the apparent stresses and both theoretical and experimental results show that the former are more accurate. The equivalent-stress formulæ are written as follows (where the subscript *e* indicates an equivalent stress, and T, C, and S represent the stresses in tension, compression and shear respectively, and *y* is Poisson's ratio) :—

Equivalent tensile stresses :

$$T_e = \tfrac{1}{2}(1-y)T + \tfrac{1}{2}(1+y)\sqrt{(4S^2+T^2)}, \quad T_e = \tfrac{1}{2}(1-y)C - \tfrac{1}{2}(1+y)\sqrt{(4S^2+C^2)}.$$

Equivalent compressive stresses :

$$C_e = \tfrac{1}{2}(1-y)C + \tfrac{1}{2}(1+y)\sqrt{(4S^2+C^2)}, \quad C_e = \tfrac{1}{2}(1-y)T + \tfrac{1}{2}(1+y)\sqrt{(4S^2+T^2)}.$$

Equivalent shear stresses :

$$S_e = \tfrac{1}{2}(1+y)\sqrt{(4S^2-T^2)}, \quad S_e = \tfrac{1}{2}(1+y)\sqrt{(4S^2+C^2)}.$$

The tensile stress formulæ should be used when P/Q is less than, and the shear stress formulæ should be used when P/Q is greater than $[(1-y)T/(1+y)\sqrt{(4S^2+T^2)}]+1$, where P and Q are the yield-points in tension and shear respectively. If the material fails in torsion with a helical-shaped fracture, the equivalent normal stress formula should be employed, and if in torsion it fails in a plane perpendicular to the axis, the equivalent shear stress formula should be used. If a material fails in tension with a decided cup-shaped fracture, the equivalent shear stress formula should be used, whereas failure perpendicular to the axis of the tension specimen indicates that the equivalent normal stress formula is preferable. J. W. T. W.

1070. *Solution of Equations by Means of the Slide-rule.* **E. W. Hollingworth.** (Inst. Civ. Eng., Proc. 202. pp. 429–438, 1915–1916.)—The equation $x^2 - ax + b = 0$ may be written in the form $x^2 = a(x - b/a)$, and this gives $2\log x = \log a + \log(x - b/a)$. The solution is obtained on the slide-rule by placing the slide with its unit-mark opposite the reading *a* on the upper scale of the rule, and moving the cursor until a point is found at which the difference between the readings on the bottom scale of the rule and the top scale of the slide is equal to b/a. The reading on the bottom scale of the rule is then the value of *x*. The approximate value of the root required is always, in engineering problems, known beforehand, so there is no difficulty about the position of the decimal point. A negative root can also be easily found, and an extension of the method may be made to solve equations of the form $x^2 = 2mr(1 - x)$, which gives the position of the neutral axis in a beam of reinforced concrete, *x* being the ratio of the depth of the neutral axis to the effective depth of the beam, *m* the modular ratio, and *r* the ratio of the area of tensile reinforcement to the effective area of the beam. Cubic equations seldom occur, but even these can be solved by the slide-rule. After transformation by removing the second term, the cubic may be written $y^3 = d(y - c/d)$, giving $2\log y + \log y = \log d + \log(y - c/d)$. To solve this, reverse the slide and place the cursor to cut the upper scale of the rule at *d*. Next, move the slide in or out until the cursor cuts the lower scale of the slide at the reading $(y-c/d)$, where y is the reading at the point at which the lower scales of the rule and slide have the same reading. Numerical examples are given, with diagrams of the slide-rule solutions. A. W.

1071. *Mechanical Theories of the Electromagnetic Field.* **A. Korn.** (Phys. Zeits. 18. pp. 823–826, July 15, and pp. 841–847, Aug. 1, 1917.)—The author here discusses his principle of individuality by which the fundamental principle of D'Alembert is modified in accordance with recent results. He first shows that in an electromagnetic field certain mechanical velocities are necessitated of the form:—$u(x, y, z, t) = u_0(x, y, z, t) + \hat{u}(x, y, z, t)$; $\hat{u} = u_1(x, y, z, t) \cos (t/\mathrm{T}) 2\pi + u_2(x, y, z, t) \sin (t/\mathrm{T}) 2\pi$, with similar expressions for v and w; these for every space element must have a definite infinitesimal density relative to the material density. The various limitations such as rigidity, incompressibility, etc., are then considered. The author points out that the classical mechanics may be extended in two directions; (1) by taking into account limitations and so approaching the ideal case by various degrees of approximation; (2) by assuming D'Alembert's principle to be an approximation only and insufficient without a correction in the case of very large velocities or very rapid vibrations. The induction method is followed in obtaining the modified principle as in the case of classical mechanics. The author shows that for the mechanical theory of electric phenomena, the new assumption of the constancy of the pulsation-amplitude is none other than to regard every electron, which behaves as a pulsating particle, as possessing a constant electric mass. The author has named his corrected expression the principle of individuality because the correction expresses the individuality of the vibrations, as opposed to the mechanical conception of constraints. H. H. Ho.

1072. *On the Time of Fall of a Stone to the Centre of the Earth.* **M. Sauger.** (Comptes Rendus, 164. pp. 954–957, June 18, 1917.)—This problem exercised the minds of geometers of the seventeenth century, *e.g.* Mersenne estimated the time of fall to the earth's centre at 6 hours; Gassendi, 20 minutes. The latter value is the more accurate. If the earth's density is assumed to be throughout of its average value 5·58, then the time of fall works out at 1284 secs. In the present note the author investigates the problem taking into account the variation of density with depth. He adopts the expression for the density variation of $\rho = 10(1 - 0{\cdot}76\, r^2/\mathrm{R}^2)$, where r is the distance to the earth's centre, and R is the distance to the surface. This function is derived from the ratio of the principal moments of inertia of the globe afforded by the precession of the equinoxes, and gives results in accord with experiments upon the intensity of gravity in mine shafts. [See Abs. 596 (1917).] With these assumptions the duration of fall is found to be 19 mins. 15 secs. The error is thus only 79 secs., when the density is assumed to be constant throughout. H. H. Ho.

1073. *Nozzle Characteristics.* **G. Flügel.** (Zeits. Vereines Deutsch. Ing. 61. pp. 650–655, Aug. 4, 1917.)—Notwithstanding many theoretical and experimental investigations into the question of the expansion of elastic media flowing through nozzles, there still remains a series of technically important phenomena which require explanation. In the present paper the nozzle-effect is examined for the case of a medium conforming to given conditions and with unrestricted exit. By nozzle characteristics the author means curves which exhibit the relationship between the reaction force or velocity coefficient at constant initial pressure before the nozzle, and either the final pressure after expansion or the adiabatic exit velocity. The average velocity first receives attention, and here the existence of the mean active velocity and its relationship to the actual mean velocity and to the square of the mean velocity, is made clear. Nozzles suitably enlarged are next dealt with, the calculation of the respective velocity coefficients being given. It is shown that the curve of velocity coefficient becomes steeper within the critical zone for increasing exit velocity. The author shows how the most favourable form of nozzle may be evolved when the conditions of flow are known. For nozzles of normal cross-section but with too small enlargement, the velocity coefficients may be calculated with perfect accuracy, and with a good approximation for nozzles of oblique cross-section when certain simplifications are made. The striking result is obtained that after decrease of back pressure, the velocity coefficient still grows and reaches its max. value for high pressures, the worse the nozzle. A limiting inferior pressure is shown for nozzles with oblique section, from which the expansion conforms to other laws as in the intermediate zone. Finally, with nozzles of too great enlargement experiments are quoted showing the improbability of the so-called direct gas impact and an indirect confirmation of this consideration is indicated. The author opines that a better solution may be sought from analogy with incompressible liquids flowing through an enlarged canal. Under this assumption a suitable approximation for the velocity coefficients is given which corresponds better with reality. H. H. Ho.

1074. *On the Flow at Weirs in the Case of Water Sheets with free Lateral Contraction.* **V. M. Hégly.** (Comptes Rendus, 165. pp. 105–107, July 16, 1917. Rev. Gen. d'El. 1. pp. 163–165, Aug. 4, 1917.)—The authors, by employing a process analogous to that of Bazin, performed a preliminary group of experiments on vertical dams with thin walls which were established in a canal of rectangular section. The coefficients of flow obtained for different heights from Dubuat's formula vary in an analogous manner with those when no lateral contraction takes place. The paper contains the data for dams of different heights, and concludes with the expression, $m = [0{\cdot}405 - 0{\cdot}030(L - l)/L + 0{\cdot}0027/h]\ [1 + 0{\cdot}55(l/L)^2\ (h/h + p)^2]$, for the rate of flow m, where l is the width of the thin vertical wall, p its height, L the width of the water canal, and h a standard weir depth from which the various constants have been obtained. H. H. Ho.

1075. *General Equation of Wave Motion.* **J. A. Fleming.** (Phys. Soc., Proc. 29. pp. 185–194; Disc., p. 194, April, 1917.)—The author gives a very simple and easy method of deriving the equation $d^2\phi/dt^2 = c^2\nabla^2\phi$, where c is the speed of propagation of the wave. In an ordinary elastic medium the stress corresponding to strain propagated by the wave may be expressed either kinetically, as $md^2\phi/dt^2$ per unit of volume; or statically, as $ed\phi/dr$, where e is an elastic coefficient, and r is a vector denoting direction of propagation. The equation of these two expressions gives the equation required. For electromagnetic waves in a pure dielectric, the strain is the electric displacement D, and if E is the electric force, then on a system of rational units, 1/K, where K is the dielectric constant, is the electric elasticity. Hence the magnetic permeability μ may be taken as corresponding to density, so that the kinetic measure of the electric stress is $\mu d^2D/dt^2$. Equating this to the space variation of the static measure of electric stress, gives, for a spherical wave from a point source, $d^2D/dt^2 = 1/\mu K \,.\, \nabla^2 D$. The wave is therefore propagated outwards without change of form, the amplitude varying inversely as the distance from the source. And this method can be applied generally, since ∇ is an invariant, unaltered in form by a shift of origin, and since by Huyghens' Principle any wave may be treated as the resultant of spherical waves from point sources. The author epitomises the method as the equation of the product of strain acceleration, $d^2\phi/dt^2$, and density to the static measure of the stress expressed as the space variation of the product of elasticity and strain slope $ed\phi/dr$, which is the proper measure of the stress at the point considered. G. W. de T.

1076. *Singular Points in the Problem of Two Bodies.* **T. Matukuma.** (Math. Phys. Soc. Tōkyō, Proc. 9. pp. 116–128, May, 1917.)—Investigations in theoretical astronomy, *e.g.* the determination of orbits, have often been made by expanding functions of the coordinates of heavenly bodies by Taylor's theorem without knowing if the series obtained were convergent. The means of determining this are, however, now available by means of Painlevé's theorem—that in the problem of n bodies the function representing their motion has singularities at a finite time t_0, which may be real or imaginary, only when one of the mutual distances between the bodies converges towards zero at that time—combined with the known fact that the radius of convergency of Taylor's series at any point is the distance from it to the nearest singular point. The author has worked the problems out fully for the case of two bodies, and calculated the values of t_0 for the major planets and for Encke's and Halley's comets—also tables facilitating the calculation for both elliptic and hyperbolic motions. G. W. de T.

1077. *Relativity of Inertia.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 19. pp. 1217–1225, 1917.)—If the gravitational action of all matter within the limits of the visible universe be neglected, and the system of reference consist of three rectangular space-coordinates, and the time multiplied by the speed of light, then in that part of the four-dimensional time-space accessible to observation, the $g_{\mu\nu}$ are very approximately those of the older relativity theory, viz., the terms in the principal area of the $g_{\mu\nu}$ matrix, taken in order, are $-1, -1, -1, +1$, and all the remaining terms are zero. Any attempt to determine the $g_{\mu\nu}$ values for points outside the accessible portion of the time-space, which extends at least to the farthest star, nebula or cluster in the spectrum of which definite lines can be identified [see Abs. 291 (1917)], can consist only of an extrapolation based upon physically unverifiable assumptions, and can therefore be of mathematical interest only. The scope of this paper is confined wholly to the consideration of attempts of this type. G. W. de T.

1078. *Geometrical Interpretation of Relativity Equations.* **L. de la Rive.** (Archives des Sciences, 43. pp. 281–284, April, 1917.)—The author observes that the fact that the equations of transformation from fixed to moving axes, when applied to stellar aberration, give a solution comprising both the angle of aberration and Doppler's principle, provides an important argument in favour of relativity. It may therefore be of interest, as he has here succeeded in doing, to show that, corresponding to this solution of the aberration problem by the relativity formulæ, a simple geometrical construction is obtainable, replacing the parallelogram whose sides are respectively the velocity of light and that of the observer in the ordinary kinematic theory of aberration. G. W. de T.

1079. *A Generalisation of W. Ritz's Analysis.* **N. Kryloff.** (Comptes Rendus, 164. pp. 853–856, May 29, 1917.)—This is a purely mathematical paper showing that Ritz's procedure may be extended to a mechanical system having any finite number of degrees of freedom with no further assumption than that the potential is expressible as a homogeneous quadratic function. G. W. DE T.

1080. *Viscosity of Liquefied Gases.* VI–IX. **J. E. Verschaffelt** [and **C. Nicaise** for IX]. (K. Akad. Amsterdam, Proc. 19. pp. 1062–1078; 1078–1079; 1079–1084, and pp. 1084–1088, 1917. Com. Nos. 151*d*, 151*e*, 151*f*, 151*g* from the Phys. Lab., Leiden.)—A continuation of a series of mathematical and experimental papers.

VI. For liquid air at 80·8° K. = −192·3° C. it is found that $\mu = 0{\cdot}956$ and $\eta = 0{\cdot}001718$.

VII, VIII are occupied with theory of methods to various approximations.

IX. The approximate value of viscosity of liquid hydrogen is found to be $\eta = 0{\cdot}00011$.

[See Abs. 151, 152, 1165 (1916).] E. H. B.

1081. *Capillary Phenomena and Supercooling.* I. *Supercooling in Capillary Tubes.* **S. L. Bigelow** and **E. A. Rykenboer.** (J. Phys. Chem. 21. pp. 474–512, June, 1917.)—In order to settle the question whether supercooling can be more easily produced and can be carried further in capillary tubes than in larger tubes, the authors have examined experimentally the max. degrees of supercooling obtainable in glass tubes with diams. varying from about ½ cm. down to about 0·2 mm. The substances employed in the investigation were sulphur, oxalic acid, orthoacettoluide, β-naphthol, and acetanilide. As a result of these experiments it was found that decidedly greater supercooling can be produced in capillary tubes than in tubes of larger diam., but the authors were not successful in formulating a mathematical connection between the amount of supercooling obtainable and the diam. of the capillary. Evidence has been obtained that the material of the tube has little, if any, effect on the degree of supercooling, and the conclusion is also reached that small changes in surface tension are of insignificant importance. In the case of sulphur the amount of supercooling depends on the temperature to which the substance was previously heated, owing to the diminution of the number of crystallisation centres produced by the presence of the different forms of sulphur, S_μ, S_π, S_{III}. A. F.

1082. *Coexistence of Matter and Energy.* **F. A. Dugan.** (Chem. News, 115. pp. 237–239, May 18, and pp. 243–247, May 25, 1917.)—Puts forward the author's own beliefs on the subject, everything in nature being regarded as chemical. L. H. W.

1083. *Orientation of Molecules in the Surfaces of Liquids.* **W. D. Harkins, E. C. H. Davies,** and **G. L. Clark.** (Am. Chem. Soc., J. 39. pp. 541–596, April, 1917.)—The molecules in the surfaces of liquids seem to be oriented, and in such a way that the least active or least polar groups are oriented toward the vapour phase. L. H. W.

1084. *Physics of the Millionth of a Centimetre.* **F. Ehrenhaft.** (Phys. Zeits. 18. pp. 352–368, Aug. 1, 1917.)—A semi-popular *résumé* of the author's work on various charged spherules which includes four photographic reproductions in addition to many diagrams and tables. E. H. B.

1085. *Effect of Molecular Bombardment of Droplets in a Gas.* **A. Targonski.** (Archives des Sciences, 43. pp. 295–306, April, and pp. 389–401, May, 1917.)—As the result of experiments in air and hydrogen (and with different pressures) and a discussion of the phenomena the following conclusions are drawn:—(1) The loss of mass of very small droplets of mercury is due to the action of the molecular bombardment, as is proved by experiments in rarefied air. (2) The rapidity of this loss is proportional to the pressure which pulverises the mercury. (3) The presence of hydrogen in the gas appears to accelerate this loss of mass. (4) The hypothesis of gentle collisions between the gas and liquid molecules is confirmed. (5) A discussion of the experimental results shows that the molecules of gas form a compressed gaseous layer at the surface of the particle. E. H. B.

1086. *The First Electron Ring of the Atom.* **P. Debye.** (Phys. Zeits. 18. pp. 276–284, June 15, 1917.)—This paper is mainly mathematical, dealing with the structure of the atom, especially with regard to the energy and number of electrons contained in the first ring of electrons surrounding the nucleus. Important references are made to the theoretical work of Bohr and Sommerfeld. The paper is divided into four principal sections:—(1) An expression for the frequency, (2) Determination of the number of electrons in the first ring—using the most reliable experimental measurements of the $K\alpha_1$ lines, (3) Considerations on the variability of electronic mass, (4) Further observations and assumptions.

As a result of his calculations the author states the extreme probability that all atoms (other than the simplest, *e.g.* hydrogen and helium) contain around the nucleus a first uni-quantum ring which consists of three electrons. A. B. W.

1087. *Proposed Gramme-Atom-Electron.* **C. Hering.** (Met. and Chem. Eng. 16. p. 598, May 15, 1917.)—The author observes that the quantity of electricity known as a *faraday* bears the same relation to the charge of a negative electron as the gramme-molecule and gramme-atom of the chemist bear to the actual molecule and gramme respectively, and suggests that it would be of assistance to the chemist to speak and write of the *faraday* as a gramme-atom-electron, and even to refer to it simply as an electron in cases where no misconception could arise—as chemists in similar cases now refer to the gramme-molecule and gramme-atom as a molecule and an atom respectively. G. W. DE T

1088. *Dependence of Air and Water Resistances on Velocity.* **H. Lorenz.** (Phys. Zeits. 18. pp. 209–214, May 15, 1917.)—Mathematical. E. H. B.

1089. *Liquid Films in Capillary Tubes.* **W. D. Bancroft.** (J. Phys. Chem. 21. pp. 407–425, May, 1917.)—In view of the results obtained by Bigelow and Hunter [Abs. 823 (1911)], the author has examined the question of the rise of liquids in capillary tubes, and has reached the following general conclusions:—(1) The rise of a liquid in a capillary tube is independent of the nature of the walls, provided the liquid wets the walls. (2) The method of Bigelow and Hunter does not give the true capillary rise, because the upper part of the tube is wanting. (3) The method of Bigelow and Hunter does not give a measure of the adhesion of the liquid to the wall of the tube because the liquid is not removed from the wall. (4) It is probable that the results obtained by Bigelow and Hunter depend on the condition under which air displaces a liquid from a wetted surface. A. F.

1090. *Local* versus *Regional Distribution of Isostatic Compensation.* **W. Bowie.** (Am. J. Sci. 43. pp. 471–475, June, 1917.)—A most important phase of the subject of isostasy is that of the distribution of the compensation of the topography, in a horizontal direction. In the computations made by the U.S. Coast and Geodetic Survey, the compensation is assumed to be directly under the topographic features. While this is not held to be strictly or even probably true, it facilitates the reductions, which, under the most favourable circumstances, require much time and labour. Certain tests are now reported in the present paper to discover the horizontal distribution of the compensation. The data from 124 stations were subjected to three tests: (1) The compensation was distributed uniformly from the station out to the limit of zone K (radius 11·7 miles). At each station the average elevation of the topography within this area was read from maps, and then the compensation of this topography was distributed uniformly throughout the circle with the given radius. (2) Similar computations were made for the average elevation of the topography from the station to the outer limit of zone M 36·5 miles. (3) This was done for the average elevation of the topography to the outer limit of zone O (103·6 miles). In making the regional method of reduction, the compensation for each topographic feature should logically be distributed separately before making the compensations to obtain its effect, but owing to its laborious nature this method would not be practicable. The compensation of the topography, therefore, beyond the areas selected for the regional distribution, was assumed to be directly under the topographic features, as is the case with the local distribution computations. In each test the gravity anomaly, *i.e.* the difference between the observed and computed values, was calculated for each of the 124 stations. If the anomalies are due entirely to departures from the truth in the method of horizontal distribution of the compensation, the author considers himself justified in concluding that that method of distribution is nearest the truth which shows the least effect of systematic errors in the anomalies for the various classes of topography. The evidence given in the paper for the Bouguer anomalies shows this method to have no general application whatever, while the data favour strongly the isostatic method of reduction, and also the local distribution of the compensation, or the regional distribution, to a distance much less than 166·7 km. H. H. Ho.

1091. *Daytime and Night-time Precipitation.* **J. B. Kincer.** (Monthly Weather Rev. 44. pp. 628–633, Nov., 1916.)—Charts are given showing the isohyetal lines for day and night precipitation over the United States. The summer months April to Sept. only are dealt with, the records from 175 well-distributed stations being used over a 20-year period. The charts show (1) day rainfall (8 a.m. to 8 p.m. 75th meridian time), (2) night rainfall, and (3) the percentage of the total fall which occurs at night. In portions of the South-eastern States only 25 % of the total fall occurs at night, while in the Central Plains from 60 to 65 % or more occurs during that time. For three representative stations the figures are worked out in greater detail. Mean hourly values are given for two of these stations. A pronounced afternoon maximum is shown at Thomasville, Ga., but a night maximum occurring at 1 a.m. at Lincoln, Nebr. The concentration of rain in the night hours in the Central Plains is advantageous to agricultural work, as rain falling in these hours is of maximum benefit for growth and produces a minimum of hindrance to farming operations. J. S. Di.

1092. *Duration and Intensity of Twilight.* **H. H. Kimball.** (Monthly Weather Rev. 44. pp. 614–620, Nov., 1916.)—Different tables for the duration of twilight have been put forward based on different assumptions for the position of the sun when twilight begins and ends. The definition here adopted for "Astronomical Twilight" is the period between the instant when the upper limb of the sun appears to coincide with the true horizon (allowing for refraction), and that when the centre of the sun is 18° below the horizon (not allowing for refraction). "Civil Twilight" is defined as ending when the true position of the sun's centre is 6° below the horizon. At this time stars of the first magnitude are just visible and darkness compels the suspension of out-door work. Tables are given showing the duration of astronomical and civil twilight in different latitudes (0°–50°) throughout the year. Curves are also reproduced showing the variation in the intensity of twilight as determined by a standard photometer. The zenith illumination was found to vary from 88 candle-ft. at the commencement of twilight to 0·4 candle-ft. at the end of civil twilight. J. S. Di.

1093. *Rainfall and Gunfire.* **A. Angot.** (French Acad. of Agriculture, J. May, 1917. Nature, 99. pp. 467–468, Aug. 9, 1917. Abstract.)—The physical changes which could be produced by the discharge of artillery and could at the same time be held responsible for the causation of rain are considered. Angot concludes that no appreciable amount of rain could be formed by either of the three following causes: (1) by the mixing of different masses of air produced by the discharge, (2) by the chemical reactions of the explosions, or (3) by the production of large numbers of ions which might form nuclei of condensation. Further, an examination of the rainfall in France since the commencement of the war shows no outstanding features which could not be accounted for by the pressure distribution existing at the times of the individual falls. J. S. Di.

1094. *Determination of Ozone and Nitrogen Oxides in the Air.* **F. L. Usher** and **B. S. Rao.** (Chem. Soc. J., Trans. 111. pp. 799–809, Aug., 1917.)—That rubber articles and textile fabrics decay much more rapidly in the tropics than in temperate climates is ascribed to the intense light and heat, and also to the supposed higher percentage of ozone, hydrogen peroxide, and oxides of nitrogen in the tropical atmosphere. As there are hardly any reliable data concerning these percentages, the authors undertook this dermination at Bangalore College in S. India. Rothmund and Burgstaller having shown that the potassium iodide method of estimating ozone and hydrogen peroxide is untrustworthy, they rely on the oxidation by ozone of alkaline or neutral sodium nitrite to nitrate, and they let the air to be analysed replace water, instead of bubbling it through water. The air is sucked through tubes charged with chromic acid (which destroys H_2O_2) and MnO_2 (neither of these two reagents attack nitrogen peroxide). Only 14 complete determinations have so far been made, and in 12 of these none of the three gases were found; twice nitrogen peroxide was observed, 1 part in 4 or in 5 million parts of air. Conclusions are not yet drawn, but it is pointed out that apparently ozone and nitrogen peroxide never occur together in the atmosphere, probably because they would react with one another under formation of nitric acid. H. B.

1095. *Comparative Study of Magmatic and Tectonic Earthquakes.* **W. Branca.** (Preuss. Akad. Wiss. Berlin, Ber. 28. pp. 880–899, 1917.)—In the introduction the author states his intention of proving that instead of most earthquakes having a tectonic origin, a considerable number can be traced to magmatic causes, and that magmatic forces have played a much greater part in geology than has hitherto been ascribed to them. Section I then deals with tectonic tremors from the standpoint of increase of temperature with depth. Two important questions here present themselves for solution, viz., at what depth does rock plasticity commence, and how is this affected by increasing temperature for the cases of dry and water-penetrated rocks? Section II examines magmatic tremors, these originating chiefly below the brittle zone in which tectonic waves have their seat. The author shows that the magmatic waves possess a greater independence of depth than the tectonic and are of a more comprehensive character; they may be subdivided into explosion, intrusion and crystallisation waves. These latter are then considered in detail, and here it is shown how confusion may arise with respect to the origin of the waves. For instance, in consequence of crystallisation, fissures may arise in the earth's crust which would cause the waves to be regarded as tectonic, whereas they are really of purely magmatic origin. Most waves are thus shown to be primarily of magmatic character and only secondarily tectonic. Section III investigates the relative age of the different wave types, finding magmatic waves to be much older than those of tectonic or solution origin. Section IV contains a criterion for deciding between magmatic and tectonic waves, viz., that the former are almost always accompanied by magnetic disturbances, whereas these are absent in the case of tectonic waves. Section V treats of changes of surface level by earthquakes. Section VI concludes the paper by a description of methods for the determination of changes at the earth's surface. H. H. Ho.

1096. *Cosmogonic Theories and Motion of Tidally-distorted Masses.* I. **J. H. Jeans.** (Roy. Astron. Soc., Mem. 62. pp. 1–48, 1917.)—The ultimate mathematical basis for the rotational hypothesis of planetary evolution consists in the facts that an isolated incompressible mass, which will presumably assume a spherical form, will, if set in rotation, continually increase its rate of rotation on account of contraction by cooling, and in so doing will first assume the form of an oblate spheroid, and gradually pass through the series of Jacobian ellipsoids with three unequal axes, into the form of a prolate spheroid. During the intermediate stage in which the axes are approximately in the ratio 23 : 10 : 8, the Jacobian ellipsoid becomes unstable, and the mass proceeds to throw off a satellite. The recent attempts to replace this by a hypothesis of the formation of satellites through tidal action, *e.g.* the Planetesimal Hypothesis of Moulton and Chamberlin, are founded on the mathematical result that the mass of matter, if subjected to tidal action by the approach of a second mass will at once become a prolate spheroid, and, in the case of a sufficiently large mass approaching from infinity, the primary would become increasingly prolate. The first question for inquiry will be whether the tidally distorted mass will become unstable, possibly with axes somewhere in the ratio 23 : 9 : 9, and whether there will be any tendency to throw off satellites. The tidal theory must ultimately stand or fall by an exhaustive investigation of this question, in which the investigation will naturally begin with the consideration of equilibrium configuration of incompressible masses, but must extend to masses which are not incompressible, and to their general dynamical treatment.

In the present instalment the author has worked out mathematically an equilibrium theory of the tides shown to be possible in two artificial cases:—(1) The case in which the matter of the primary is supposed perfectly homogeneous and incompressible. (2) A case which may be thought of as representing the limit of non-homogeneity and incompressibility, the primary being supposed to consist of a small core of finite density surrounded by matter of negligible density. The primary is considered throughout as a fluid, but the results will hold good without much modification for a solid or a gas. If the primary be a solid of astronomical dimensions, the tidal forces will in general be so great that no rigidity, unless enormously greater than anything known in nature, could resist the stresses set up, and the solid would adjust itself, much in the same way as a fluid, until its surface became approximately an equipotential. The results of the mathematical investigation are found to be surprisingly little affected by the heterogeneity or compressibility of the matter of the primary, as well as of the ratio M/M_0 of the secondary to the primary mass. In each case a series of configurations exist, differing little from prolate spheroids, which remain stable until the distance R between the centres of gravity of primary and secondary falls to a critical value R_0, after which there are no equilibrium configurations, stable or unstable. When R changes slowly enough an equilibrium theory will give a good approximation to the truth. For rapid change in R a dynamical treatment is necessary, as it is in all cases for determining the motion when $R < R_0$. The author has not succeeded in treating case (2) dynamically, but has obtained a solution in case (1) when the tide-generating potential is expressed by the first term of its harmonic expansion; and has then extended the solution so as to examine the motion when the potential contains terms of the third and higher orders, and so is of the most general type which can occur in a natural problem. Moreover, in case (2), where R changes slowly, the motion is readily seen, without detailed analysis, to be of the same general nature as in case (1), and there appears to be no reason why it should materially differ when R changes more rapidly. The results of the analysis, in the light of existing astronomical knowledge, lead the authors to the conclusions that:—(1) The normal binary-star formation cannot be explained as the result of tidal action; the genesis of such systems must be ascribed to rotation. (2) The normal spiral nebula shows some features which can be explained qualitatively in terms of tidal action, somewhat after the manner of the Planetesimal Hypothesis, but on the whole it seems impossible to reconcile this explanation with the known facts of astronomy. (3) The genesis of our solar system can very probably be attributed to tidal action; the explanation leaves room for a good deal of uncertainty in matters of detail, but does not demand anything impossible or very improbable. The evidence obtained suggests that a system generated by tidal action might quite well have characteristics, both qualitative and quantitative, such as are observed in our system. The origin which seems most probable is not that of the Planetesimal Hypothesis. G. W. de T.

1097. *The Structure of High-standing Atolls.* **W. M. Davis.** (Nat. Acad. Sci., Proc. 3. pp. 473–479, July, 1917.)—The structure of high-standing atolls has seldom been studied in detail, and is perhaps seldom sufficiently revealed for close study. Attention is drawn in the present paper to only one structural feature, namely, the relation of atoll limestones to their supposed foundation of volcanic rocks. According to Darwin's theory of intermittent subsidence, the limestones of atolls should lie unconformably on an unevenly eroded, sub-mountainous volcanic mass, the top of which may be buried to any depth. According to the glacial-control theory, which Davis considers to be the only fully formulated competitor of Darwin's theory that deserves consideration here, the limestones of atolls should as a rule unconformably overlie a flat platform of volcanic and calcareous rocks by a series of processes which the author describes in detail with several illustrations. It is evident that no great amount of erosion could take place in Postglacial time, so that the uplifted atolls which are much dissected were uplifted during the glacial period, and then deeply dissected by sub-aerial erosion and benched by marginal abrasion during the last glacial epoch of lowered sea-level, so that when the sea finally rose in Postglacial time, an outstanding barrier reef would grow up around the margin of the last abraded marginal bench and enclose a lagoon, the waters of which would enter narrow embayments in the central island. In case an island were dissected sufficiently to show its abraded platform of central volcanic rocks surmounted by residual limestone hills, a still earlier uplift would be demanded and a correspondingly shorter part of the glacial period would be allowed for the initial abrasion of the volcanic island. The author then considers a series of examples in order to test his theory. H. H. Ho.

1098. *Notes relating to the Earthquake of Oct.* 18, 1916, *in North Central Alabama.* **R. H. Finch** and **O. B. Hopkins.** (Monthly Weather Rev. 44. pp. 690–693, Dec., 1916.)—The earthquake occurred a little to the north-east of Birmingham, Ala., and the influence of the geologic structure on the propagation of the earthquake waves is shown by the fact that the effect was felt 340 miles to the north and to the east, 190 miles to the south, and only 130 miles to the west. The duration of the first shock has been variously estimated at from less than 30 secs. to more than 1 min. The most interesting effect of the earthquake was the drying up of a number of heretofore unfailing wells, and the lowering of the water-level in others. The direction of movement, the intensity of the shock, and the effect upon the underground water near Irondale, suggest that the locus of the disturbance which produced the earthquake was along the Red Gap fault, which runs through Irondale; and that the movement along this fault was horizontal rather than vertical. Had the movement along this fault been vertical, the direction of the resultant vibrations would have been at right angles to the line of fault, or approximately N. and S., instead of E. and W. as it was found to be. The occurrence of a fissure in one of the wells may have been the result of this horizontal or torsional movement. H. H. Ho.

1099. *Dissipation of Energy in Tides.* **R. O. Street.** (Roy. Soc., Proc. 93. pp. 348–359, July 2, 1917.)—An expression is obtained for the rate of dissipation of kinetic energy in a rotating sea, in the form of an integral of a function of the surface-current velocities. The method has been used to find the rate of dissipation in the Irish Sea, for which detailed tide information is available; the order of magnitude of the result suggests that this direct effect of viscosity may account for at least part of the earth's secular retardation. C. P. B.

1100. *Oceanic Tidal Friction.* **H. Jeffreys.** (Nature, 99. p. 405, July 19, 1917.)—Referring to a paper on dissipation of energy of tides by R. O. Street [see preceding Abs.], the tidal friction in mid-ocean is thought to be insufficient to account for any great part of the observed lunar acceleration. C. P. B.

1101. *Determination of Latitude and Declinations.* **C. Sanders.** (Observatory, No. 515. pp. 271–273, July, 1917.)—In circumstances where ephemerides are not available, it is proposed to determine latitude and declinations by combining observations of the azimuth of elongation (of stars culminating between the elevated pole and the zenith) and the meridian zenith distance. The necessary formulæ of reduction are given, showing that the method is suitable for low latitudes in which azimuth can be determined with great precision. A similar method, adapted for higher latitudes, consists in the observation of the zenith-distance in the prime vertical combined with the meridian zenith-distance. Small meridian zenith-distances should be avoided. The instruments recommended consist of a fair-sized altazimuth, solidly mounted, and a reliable azimuth mark. C. P. B.

1102. *Solar Prominences.* **J. Evershed** and **Mrs. J. Evershed.** (Kodaikanal Observat. Mem. 1. Pt. 2. Observatory, No. 518. pp. 359–364, Oct., 1917.) Nature, 99. p. 432, July 26, 1917. Abstract.—During the period 1890–1914 the total number of prominences observed at Kenley and Kodaikanal was about 71,000, and during the latter part of the interval the denser prominences have also been photographed as absorption markings on the disc. The discussion indicates the existence of two belts in each hemisphere which are specially prolific in prominence activity. The low-latitude belts are coincident with the sun-spot zones, and their variation in number is in general phase agreement with the spot variation. In the high-latitude belts the frequency is greatest between spot-minimum and spot-maximum, gradually moving poleward and reaching the pole about spot-maximum, to re-form in lat. ± 59°. Prominence forms are classified according to size and shape, and reproductions are given from numerous photographs. C. P. B.

1103. *Elements of Sun's Rotation.* **T. Epstein.** (Astron. Nachr. No. 4892. Nature, 99. p. 493, Aug. 16, 1917. Abstract.)—Based on observations of 58 spots in various latitudes, made during the period 1908–1910, a new determination of the sun's axis has been made. The longitude of the ascending node of the equator is found to be 73° 59·2′, and the inclination of the axis to the ecliptic is 82° 43·7′. These are in close agreement with Carrington's old values, and there will be no necessity to revise the existing tables for physical observations of the sun. C. P. B.

1104. *Average Parallax of Stars of Fourth Type.* **H. E. Laŭ.** (Astrophys. J. 45. pp. 348–350, June, 1917.)—Referring to Kapteyn's determination of the average parallax of stars of the fourth type [Abs. 1588 (1910)], it is shown that the data used were not reliable, owing mainly to defects in the old meridian circle at Copenhagen Observatory. The imaginary character of the proper motions is shown by their rapid increase with the magnitude of the stars. C. P. B.

1105. *Recent Changes in Variable Nebula N.G.C.* 2261. **E. P. Hubble.** (Astrophys. J. 45. pp. 351–358, June, 1917.)—This nebula was found to be variable by comparison of photographs taken with the 24-in. Yerkes reflector in 1908 by F. C. Jordan, and in 1915–16 by the author [Abs. 118 (1917)]. Examination of a plate taken by H. D. Curtis with the Crossley reflector at Lick in Jan., 1913, showed that the entire change had occurred between 1908 and 1913. The nebula apparently remained quiescent until 1916. Subsequent photographs indicate that the activity has been renewed, resulting in a considerable fading of the southern perimeter. The nucleus of this is the variable star R Monocerotis, of irregular period, and range of magnitude from 9·5 to 13·0. C. P. B.

1106. *Relationship of Stellar Motions to Absolute Magnitude.* **W. S. Adams** and **G. Strömberg.** (Mt. Wilson Solar Observat., Contrib. No. 131. Astrophys. J. 45. pp. 293–305, June, 1917.)—The recent development of a spectroscopic method of deriving absolute magnitude is utilised for an investigation to discriminate between the two alternative hypotheses (1) that velocity is a function of absolute magnitude, or that the intrinsically faint stars move more rapidly than the bright stars; (2) that the nearer stars move more rapidly than the distant stars. It is concluded that radial velocity is a function of absolute magnitude for the 1800 stars considered, the increase in velocity being about 1·5 km. for a decrease in brightness of one magnitude. The giant and dwarf division among the K and M stars is indicated clearly in the absolute magnitudes. The stars of types K and M have mean velocities about 1·0 or 1·5 km. higher than the F and G stars of the same absolute magnitude. C. P. B.

1107. *Visual and Photographic Observations of Eclipsing Variables.* **H. N. Russell, M. Fowler, and M. C. Borton.** (Astrophys. J. 45. pp. 306–347, June, 1917.)—First results are given of a co-operative plan for the measurement and discussion of the stars contained in the plates of the Harvard Photographic Library. Six eclipsing variables are under discussion, and the observations of photographic and visual brightness are compared, it being found possible in all cases to find satisfactory geometrical elements for both series. It is shown that the Harvard plates contain material for accurate light-curves for all regular variable stars brighter than the twelfth magnitude. It is found that the epochs of mid-eclipse differ for the visual and photographic observations, and no satisfactory explanation of this is at present available. C. P. B.

1108. *Variable Proper Motion of δ Cassiopeiæ.* **L. Courvoisier.** (Astron. Nachr. No. 4891. Nature, 99. p. 464, Aug. 2, 1917. Abstract.)—From a discussion of the Pulkova observations of this star (which Guthnick has found to be an eclipsing variable with a period of 2·1 years), it is shown that there exists a variation in the proper motion, the amplitude in declination being $0.04''$. The deduced parallax of the star is $+0.11''$. C. P. B.

1109. *Variable Star u Herculis.* **W. Dziewulski.** (Astron. Nachr. No. 4887. Nature, 99. p. 418, July 19, 1917. Abstract.)—From observations at the Cracow Observatory with a 4-in. comet-seeker, it is concluded that this star is a variable of the β-Lyræ type, with a period of slightly more than 2 days. The light-curve is slightly unsymmetrical. C. P. B.

1110. *Radiation of the Stars.* **J. H. Jeans, A. S. Eddington.** (Nature, 99. p. 365, July 5, 1917.)—Criticism is given of a paper by A. S. Eddington [Abs. 888 (1917)], on the assumed relation formulæ between radiation-pressure and gravity. (Ibid. pp. 444–445, Aug. 2, 1917.)—Jeans considers that the assumption of a steady state as basis for calculation of stellar radiation is unacceptable. Eddington has rearranged his analysis, which will be published later. C. P. B.

1111. *Rotation in Planetary Nebulæ.* **W. W. Campbell and W. H. Moore.** (Popular Astron. 25. p. 318, 1917. Nature, 99. p. 375, July 5, 1917.)—Photographs of the spectrum of the planetary nebula N.G.C. 7662 show that the bright lines are doubled in the central portions of the nebula, the explanation given being that the lines are widened by the differential radial velocities in the central portions, and that an outer stratum of absorbing nebulosity, with a slower rotation, produces an absorption line lying nearly central along each bright line. It is also found that the nebula N.G.C. 7026 is rotating rapidly, and that it has an outer equatorial zone of absorbing matter. C. P. B.

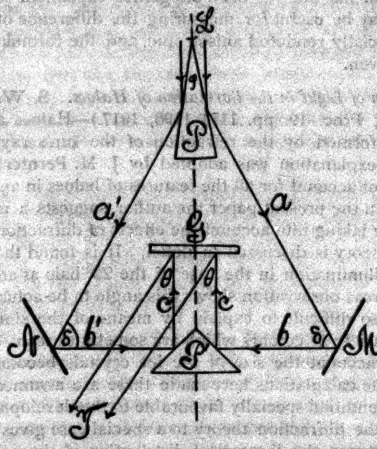
LIGHT.

1112. *Artificial Double Refraction in Cylindrical Bodies.* **W. König.** (Ann. d. Physik, 52. 6. pp. 553–607, July 17, 1917.)—A description is given of a simple method by means of which a gelatine cylinder may be subjected to stress such that the principal stress at all points has the same direction. The double refraction thus brought about is greatest at the centre, and decreases radially according to the simple function $a - br^2$, where a and b are constants for any particular case. The theory of this phenomenon is considered in relation to the ordinary laws of elasticity, an approximate solution being first obtained, and finally a complete solution is deduced by means of infinite series. Comparison of the theoretical and experimental results shows a complete qualitative agreement, but quantitatively there are small discrepancies, of which the origin has not yet been altogether explained. It is suggested that the method may be useful for measuring the difference of susceptibility in substances artificially rendered anisotropic, and the formulæ required for this purpose are given. A. W.

1113. *Diffraction of Light in the Formation of Haloes.* **S. W. Visser.** (K. Akad. Amsterdam, Proc. 19. pp. 1174–1196, 1917.)—Haloes are commonly considered to be formed by the refraction of the sun's rays through ice crystals, and this explanation was adopted by J. M. Pernter among others. This theory does not account for all the features of haloes in an entirely satisfactory manner. In the present paper the author suggests a modification of the usual theory by taking into account the effects of diffraction.

The ordinary theory is discussed in detail. It is found that it leads to a max. intensity of illumination in the case of the 22° halo at an angle of 22¼° from the sun, whereas observation shows this angle to be actually a little less than 22°. It is also difficult to explain by means of the simple refraction theory the great variety of colours which are sometimes seen. When diffraction is taken into account the size of the ice crystals becomes a matter of importance. In the calculations here made these are assumed to be homogeneous in size, a condition specially favourable to the development of colour. An application of the diffraction theory to a special case gives very satisfactory agreement between the theoretical distribution of the colours and that actually observed. The side of the hexagonal ice crystal is calculated in this case to be 0·279 mm. It is found that very small crystals will lead to a halo which has a red inner edge and in which no other colour is seen but white, while larger crystals produce more distinct colouring. It is urged that accurate observations of the colouring of haloes should be made, as without this information reports are of little or no value. J. S. Di.

1114. *Interferometer Methods based on the Cleavage of a Diffracted Ray.* **C. Barus.** (Nat. Acad. Sci., Proc. 2. pp. 475–478, Aug., 1916.)—The prismatic method of cleaving the incident beam of white light renders possible the superposition of non-reversed spectra, under conditions where the paths of the component rays may have any length whatever. It is thus an essential extension of the same method as used for reversed spectra heretofore, and also of the methods in which the paths are essentially small. In the Fig., P is the first prism cleaving the white beam L diffracted by the slit of a collimator. The half-beams reflected from the two sides of P fall on the opaque mirrors M and N, and are again reflected so as to fall on opposite faces of a second prism P′, made right-angled for ease in adjustment, though a small angle would be better. The rays reflected from P′ impinge normally on the reflecting grating G (grating space $D = 200 \times 10^{-6}$) and are observed by a telescope at T. M is on a micrometer, and P′ must be capable of being raised, lowered, and moved fore and aft. The field is brilliantly illuminated. When the path difference is sufficiently small, fringes appear and cover the whole length of superposed spectrum, strongly. They are displaced with rotation if M is moved normally to itself. Assuming the component beams to have the width of the pencil diffracted by the slit of the collimator, the max. size of fringes will occur when *c* and *c′* are as near together as possible. To get the largest fringes, M must be moved towards P′ until *c* reaches the edge of P′, and very sharp-angled prisms must be used at both P and P′. Fringes of similar character were obtained before with two identical half-gratings, when one was displaced normal to the common plane, but the fringes and available paths were small. Large fringes, but still with small paths, were



obtained with two identical transmitting gratings superposed. If the prism P′ is right-angled, it may be rotated through 180°, so that the rays *c* and *c′* pass off towards the rear. They are then observed through an Ives' prism grating and a telescope. This method admits of much easier adjustment. A fuller report of the work has been presented to the Carnegie Institute of Washington.

A. E.

1115. *Maintaining Photographic Standards.* **A. B. Hitchins.** (Frank. Inst., J. 184. pp. 179–204, Aug., 1917.)—Photography is so generally practised by technical workers that it is thought a description of the methods employed for the determination and upkeep of the quality of light-sensitive materials may prove of interest. An endeavour is therefore made in this paper to describe just how speed readings are determined, and precisely what they mean. The various kinds of sensitometer employed are described. The terms transparency, opacity, and density, as used in reference to testing emulsion speeds, are explained and the relationship between them is dealt with in detail. The practice of a system of emulsion speed measuring is based on the inter-relation of the before-mentioned definitions. To apply these practically in plate speed measurements four instruments are required: (1) Some form of standard light for making the exposures, (2) an exposing machine used in conjunction with the standard light for impressing the plates with a series of known exposures, (3) a thermostat for maintaining the developing solutions at constant temperature, (4) some form of photometer for reading the densities of the plates made in the exposing machine. Each of these is next considered and the method of plate speed measuring is dealt with at some length. A short account is also given of the recent modification of the plate-testing system as applied to the determination of the character of developing-out paper emulsions. A. E. G.

1116. *Photomicrographs in Colour.* **C. E. K. Mees.** (Frank. Inst., J. 184. pp. 811–812, Aug., 1917.)—Lantern slides representing photomicrographs of stained sections should, in order to give satisfaction, closely resemble the appearance of the section itself. This can be attained by making the print in stained gelatine instead of by the usual photographic process. The process of making such a print is as follows:—Lantern plates are sensitised by bathing for 5 mins. in a 2½ % solution of ammonium dichromate containing 5 cm.^{3} of strong ammonia to the litre, the temperature of the bath being not above 65° F. The plates are then rinsed for 2 or 3 secs. in clean water, drained, and dried as uniformly as possible, the plates being kept in the dark during drying. The sensitised plates are then exposed through the glass under the negative to the light of an arc lamp, the average exposure being about 3 mins. at 18 in. distance. Printing cannot be done by daylight, or sharp images will not be obtained. The exposed plates are then developed by rocking in trays of water at about 120° F. until all soluble gelatine is removed. Under-exposure is indicated by the high-light detail washing away, and over-exposure by the film being insoluble to too great a depth. The plates are then rinsed in cold water, fixed in hyposulphite, and washed free of the latter. They are then ready for staining. The staining is done with a 1 % solution of dye containing 1 % of acetic acid, the dye being selected to simulate most closely the original stain of the section, and the time of dyeing being chosen so that the necessary depth is obtained. When sections stained with two different colours are being photographed negatives are made through suitable colour-filters and are then dyed in the two stains and placed face to face so that a two-colour slide is obtained. The choice of the filter is decided by visual trial under the microscope, the filters chosen being those which most nearly absorb one colour and transmit the other. A. E. G.

1117. *Mechanical Equivalent of Light.* **W. W. Coblentz and W. B. Emerson.** (Bureau of Standards, Bull. 14. pp. 255–265 [Sci. Papers No. 305], 1917.)—Gives some applications of the curve of visibility of radiation for the average eye (125 observers) to radiation problems. A mathematical equation is given of the average visibility curve. Using this visibility equation and Planck's equation of the black body, calculations are made of the luminous flux emitted by such a body at various temperatures, also the luminous efficiency, the Crova wave-length, and the mechanical equivalent of light. The visibility curve of the average eye gives the value for the least mechanical equivalent of 1 lumen = 0·001627 watt of luminous flux of max. luminous efficiency (the least mechanical equivalent is the ratio of the candle or lumen to the watt for monochromatic radiation having the wave-length of max. visibility). The two determinations of the least mechanical equivalent of light made by Ives, Coblentz, and Kingsbury [Abs. 888 (1915)] are corrected. The values obtained by their two methods of measurement, using 61 observers, are in exact agreement, giving 1 lumen = 0·001606 watt.

A further determination of the least mechanical equivalent of light was made by using a standardised vacuum tungsten lamp as a source of radiation. The measurements on this lamp gave a value of 1 lumen = 0·00157 watt of radiant energy of max. visibility. These computations are based on the most probable values of the radiation constants: $C_2 = 14{,}350$ micron deg. and $\sigma = 5{\cdot}7 \times 10^{-12}$ watt per cm.^{2} per deg.^{4}. On this basis the most reliable data now available indicate that the value of the luminous equivalent of radiation of max. luminous efficiency is of the order of: 1 watt = 617 lumens = 49·1 candles, 1 lumen = 0·00162 watt of luminous flux. Among other data this paper gives the determination of the radiant luminous efficiency of a vacuum tungsten lamp, the value being 1·42 % when operating at 1·23 watts per candle. J. W. T. W.

1118. *Radiation-pressure and Relativity.* **J. Larmor.** (Nature, 99. p. 404, July 19, 1917.)—Poynting's conclusion (Roy. Soc., Phil. Trans. 1903) that the radiation from a material body in space gives rise to a small retarding force, which acts cumulatively as a brake on its movement through the ether, has been stated to contradict electromagnetic theory, because, for an isolated radiator like a star, this force of radiation is specified as proportional to its velocity through the ether, and this is said to violate the principle of relativity. But Poynting's principle has nothing to do with the refined second-order negative results which led to the relativity hypothesis, his effect being proportional to the first power of the velocity, and thus a direct consequence of the original Maxwellian theory, now universally accepted. It can fairly be said, however, that none of the original enunciations of the relativity hypothesis seek to apply the principle that all motions are relative to systems not self-contained. Poynting's principle and its cosmical results seem to stand firm on established laws, and *a priori* views as to relativity must adapt themselves to it. Any attempt in that direction will have to take account of the inertia of free travelling radiation. G. W. DE T.

1119. *Physical Basis of Colour-technology.* **M. Luckiesh.** (Frank. Inst., J. 183. pp. 73–98, July, and 184. pp. 227–250, Aug., 1917.)—In this paper the author gives a discussion of the methods of analysing colour, and of the general characteristics of pigments, dyes, and coloured glasses. The laws of absorption and their uses are next dealt with, and numerous tables are given of spectral analyses of the visible radiation reflected by pigments and transmitted by dye-solutions and coloured glasses. The uses of such data are discussed, and emphasis is laid on the importance of a physical basis in colour-technology, the general trend of evidence indicating that the chemistry of coloured media at present greatly dominates the physics. Much might be gained if the physics of colour was more generally understood. A. W.

1120. *Stereoscopic Colours.* **M. Luckiesh.** (Frank. Inst., J. 183. pp. 773–775, June, 1917.)—Objects of different colours tend to appear to be located at different distances from the eye, even when actually placed in the same plane. This is generally ascribed to chromatic aberration. The author has tested this by observations on two letters, illuminated respectively by red and blue light, the distances of which from the eye could be conveniently altered and measured. A number of observers were asked to displace the letters so that they appeared equally distant. In seven cases observers stated that the red letter appeared closer than the blue one, when they were actually equidistant. This could be explained on the basis of chromatic aberration, but in two other cases the converse effect was noted. It was shown that when a small artificial pupil was placed in front of the eye, the effect could be reversed or the two images apparently brought into the same plane, according to the position of this artificial pupil. It would therefore appear that such differences between observers may be due to differences in the shapes and relations of the various parts of the eye, such as curvatures, eccentricities of pupils, etc. J. S. D.

1121. *Explanation of Persistence of Vision as a Physical Conduction Phenomenon.* **H. E. Ives.** (Frank. Inst., J. 183. pp. 779–780, June, 1917.)—The author, in conjunction with Kingsbury, has suggested that persistence of vision can be explained on a physical basis assuming sluggishness of the visual apparatus introduced by the transmitting medium [Abs. 299 (1915)]. An alternative assumption is that inertia is a property of the surface at which the reaction due to light takes place, and equations are here developed expressing this condition. Any equations indicating the nature of visual processes should represent the damping effect, to which persistence of vision is due, as located in a conducting medium. J. S. D.

1122. *Focometry of Lens Combinations.* **A. Anderson.** (Phil. Mag. 34. pp. 76–80, July, 1917.)—A reply to R. E. Baynes' note [see Abs. 488 (1917)], showing that the discordant results obtained are due to experimental inaccuracies rather than to a defect in the method. In an additional note, an account is given of a method of finding the distance between the principal points of the combination to a greater accuracy than is possible with the method previously described [see Abs. 215 (1917)]. J. W. T. W.

1123. *Refraction of Thin Axial Pencils through Symmetrical Optical Systems.* **A. Anderson.** (Phil. Mag. 34. pp. 174–177, Sept., 1917.)—Describes some further properties of a point (now termed by the author the "nul point") of a lens-combination, the use of which for the determination of the constants of the combination was described in a previous paper [see Abs. 215, 488 (1917) and preceding Abs.]. J. W. T. W.

1124. *Chromatic Parallax and its Influence on Optical Measurements.* **J. Guild.** (Phys. Soc., Proc. 29. pp. 311–335; Disc., 335–338, Aug., 1917.)—Describes various parallax effects observable when objects illuminated by light of different colours are seen through a "pinhole" of smaller diameter than the pupil of the eye. The effects are due to the well-known chromatic aberration of the eye; and it is shown that in most optical instruments of precision the necessary conditions for parallax of this nature are present when observations are made in the blue and violet; and that this results in a serious diminution of the accuracy of such measurements. Several methods of obviating the difficulty are described. AUTHOR.

1125. *Geometrical Optics in Moving Bodies by Vector Calculus.* **P. Frank.** (Ann. d. Physik, 52. 6. pp. 649–656, July 17, 1917.)—This mathematical treatment consists of three parts dealing respectively with the following topics: (1) The deviation of the light from its path in stationary inhomogeneous bodies. (2) The relative curvature of the light rays through the ether "wind." (3) The influence of the earth's motion on the radiation phenomena. [See Abs. 1146 (1911).] E. H. B.

1126. *Colour Apparatus.* **A. v. Hübl.** (Phys. Zeits. 18. pp. 270–275, June 15, 1917.)—Describes a compact colour-mixing apparatus which may be used to match the colour of a given body. White light in three parallel beams is admitted through red, green, and blue filters, and the resulting beams are reflected along the same path by half-silvered glasses. The amounts of light admitted to such filters are adjusted by wedges of neutral-tinted glass. Light from the body to be matched is admitted by another side path for comparison. [See Abs. 1342 (1916).] E. H. B.

1127. *Mechanism of Colour Vision.* **J. Guild.** (Phys. Soc., Proc. 29. pp. 354–361, Aug., 1917.)—A criticism of Houstoun's theory.

1128. *Atmospheric Reflections.* **F. Nölke.** (Phys. Zeits. 18. pp. 134–144, April 1, 1917.)—Discusses by aid of 15 diagrams the theory of the reflections of light which may occur in special states of the atmosphere, and so give rise to mirage effects. E. H. B.

1129. *Dispersion of Carborundum.* **H. E. Merwin.** (Washington Acad. Sci., J. 7. pp. 445–447, Aug. 19, 1917.)—The ordinary and extraordinary indices of refraction for carborundum were determined for 12 values of wave-length from 755 $\mu\mu$ to 416 $\mu\mu$. None of these indices exceed the limits 2·616, 2·812; the indices for the greatest λ being 2·616 and 2·654, those for the smallest λ being 2·757 and 2·812. E. H. B.

1130. *Effect of Molecular Impacts on the Spectra of Gases.* **G. Gouy.** (Comptes Rendus, 165. pp. 17–21, July 2, 1917.)—The molecules of a gas caused to emit light possibly produce regular vibrations, but the final result is modified (1) by the Doppler-effect due to the velocity of the molecules, and (2) by the impacts which the molecules undergo, the impacts producing a sharp and fortuitous variation of phase and amplitude. The above hypothesis may not be rigorously in accordance with the actual facts, but a comparison of the conclusions derived therefrom with what is actually observed may throw light on the mechanism of emission. The author proposes to examine successively (1) interferences with large path-difference, (2) the law connecting the intensity of a spectral line and its width with the thickness of the gas layer, and (3) the continuous spectra which accompany certain spectral lines and depend on them. Michelson's formulæ for visibility, etc., are obtained on the supposition that the time between two successive impacts is constant. But the visibility formula for the impacts alone can be derived without using Fourier's series and without assuming a uniform interval between the successive impacts. The formula thus obtained is $V_2 = e^{-hX/c}$, where c is the velocity of light, X the path-difference in air, and the probability of an impact occurring during the time dt is hdt. From a table of values of V_2 it appears that the practical limit of visibility of fringes, resulting from impacts alone, is three or four times greater than that indicated by the hypothesis of a constant interval between impacts. A new formula for visibility is also derived in which account is taken of the admixture with the first gas of a certain proportion of a second gas in which the mean free path is L, and this new formula is compared numerically with Michelson's in the following table :—

X/λ_0	5×10^4	8×10^4	1×10^5	$1{\cdot}2 \times 10^5$	$1{\cdot}5 \times 10^5$
V_2 (M)......	0·895	0·098	0·024	0·0047	0·00028
V_2 (G)	0·607	0·278	0·151	0·078	0·020

V_2 (G) refers to Gouy's and V_2 (M) to Michelson's formula. According to the new formula, the visibilities 0·5 and 0·05 should be obtained respectively for the values 8·8 and 7·6 cm. of X. To give the same visibilities for the same values of X with Michelson's formula it would be necessary to put $L = 2{\cdot}5\lambda_0$ or $L = 5{\cdot}8\lambda_0$. Michelson's formula thus appears to give great values to L as a function of the visibility, and the difference would be greater still if Gouy's full formula is used instead of the approximate one from which the above numerical values are derived, which formula gives values of V_2 slightly too small for the low visibilities. A. W.

1131. *Wave-lengths of the Stronger Lines in the Helium Spectrum.* **P. W. Merrill.** (Bureau of Standards, Bull. 14. pp. 159–166 [Sci. Papers, No. 302], 1917. Chem. News, 116. pp. 130–133, Sept. 14, 1917.)—The investigation here described is part of the standard wave-length programme of the Bureau of Standards, which is at present chiefly concerned with the spectra of iron, argon, and neon. Precise measurements of the stronger helium lines were undertaken in order that they may serve as standards for the determination of other wave-lengths, and to furnish a basis for theoretical work on series formulæ. The wave-lengths of 21 lines were determined accurately by interference methods, 9 of the lines being compared directly with the red cadmium line. The possibility of eliminating the effect of apparent variation of interferometer thickness with wave-length is noted. Calculations based on the wave-lengths obtained show that the Kaiser and Runge formula for spectral series, based upon three consecutive lines, will not reproduce accurately even the next member in any one of the six helium series. A. W.

1132. *Spectra of Hydrogen and Helium.* **T. R. Merton** and **J. W. Nicholson.** (Roy. Soc., Phil. Trans. 217. pp. 237–278, Aug. 11, 1917.)—A continuation of previous work [Abs. 1037 (1916)]. The authors have developed a method for the accurate determination of the photographic intensities of spectrum lines, and the reduction of such intensities to absolute values by comparison with the continuous black-body radiation of the carbon arc. A study has now been made of the relative intensity distribution in the spectra of helium and hydrogen under different conditions of excitation, and it has been found that under certain specified conditions there is a transfer of energy from the longer to the shorter wave-lengths in any given series, and that under such conditions the associated series, and in particular the diffuse series, are relatively enhanced at the expense of the principal series. It has also been found that the distribution of intensity found in certain celestial spectra can be approximately reproduced in the laboratory. A study has been made of the separations of the components of lines of the Balmer series of hydrogen, and the mean values of the separations of the doublets constituting the lines H_α and H_β were found to be respectively 0·132 and 0·033 Å. unit. These values are consistent with the separations appropriate to principal series, and the first is in precise agreement with the value deduced by Buisson and Fabry. These results lend no direct support to the theoretical considerations advanced by Sommerfeld, and show that the Balmer series can no longer be regarded as either a sharp or a diffuse series. A. W.

1133. *Spectroscopic Comparison between the Theory of Fixed and Deformable Electrons.* **K. Glitscher.** (Ann. d. Physik, 52. 6. pp. 608–630, July 17, 1917.)—In the first part of this paper formulæ are obtained for the fine structure of spectral lines like the hydrogen lines, based on Bohr's model atom and Sommerfeld's theory of fine structure. These formulæ are sufficiently accurate for a first approximation. The calculation is carried out so that the expressions for the impulse and kinetic energy of the electrons appearing in Bohr's model atom depend on powers of $\beta = v/c$. In the final formulæ the corresponding values given, first by Abraham's and then by Lorentz's electron theory for the as yet unknown coefficients, are introduced. A comparison with Paschen's measurements shows that the essential features of the observed fine structure can be readily accounted for by means of the formulæ of the relativity theory with the best values of the universal constants N, e and h, as Sommerfeld also found, and that, on the contrary, Abraham's theory will not yield results of the right magnitude for the fine structure with any admissible values of e and h.

In the second part of the paper a second approximation is derived, and applied to the doublet of the L-series of the Röntgen spectra to calculate the so-called L-term. The final formulæ are so arranged that numerical values obtained either from the theory of deformable or of fixed electrons may be introduced. The latter gives for the term denominator the value 1·892 instead of 2·002. The similarity of the doublets of the L-series to the hydrogen lines is therefore lost if the theory of fixed electrons is adopted.

A. W.

1134. *Ionising Potential of Sodium Vapour.* **R. W. Wood** and **S. Okano.** (Phil. Mag. 34. pp. 177–183, Sept., 1917.)—The experiments of Franck and Hertz, McLennan and others have shown that when the vapours of Hg, Cd, Zn, and Mg *in vacuo* are bombarded by electrons from a hot kathode, a single-line spectrum is emitted, provided the kinetic energy of the electrons does not exceed a certain critical value. The authors have now carried out an extensive series of experiments with the vapour of sodium, and conclude from these that the D lines appear when the potential between the hot kathode and the wire is 0·5 volt or more. As this value is so much below that required by the quantum relation (2·1 volts), it was necessary to make sure that the emission of the D lines was not due to some secondary action, such as the light from the incandescent filament. Various experiments showed that the D lines could not be ascribed to any such secondary action. The experiments show, then, that the D-line emission results from the application of a potential of 0·5 volt or more, the subordinate series appearing at about 2·8 volts. A. W.

1135. *Phosphorescent Zinc Sulphide.* **E. MacDougall, A. W. Stewart,** and **R. Wright.** (Chem. Soc. J., Trans. 111. pp. 663–683, Aug., 1917.)—Ordinary precipitated zinc sulphide shows no phosphorescence and heat is necessary to produce this condition. Thus the zinc sulphide produced by deflagration of measured quantities of zinc and sulphur is phosphorescent, but the best effect is secured by precipitation under suitable conditions, the precipitate being subsequently heated to between 650° and 900° C. for a time not exceeding an hour and a half. The material produced below 650° is viscous and amorphous, that between 650° and 900° semi-crystalline, and that above 1100° purely crystalline. Temperature also affects the colour of phosphorescence, specimens prepared at 650° giving blue light, whilst higher temperatures lead to greens and even yellows. The phosphorescence of pure zinc sulphide is relatively weak and brighter effects are produced by the addition of small quantities of suitable impurities such as sodium chloride. Other impurities such as iron are prejudicial to phosphorescence, while manganiferous zinc sulphide gives a golden-yellow phosphorescence and also exhibits strong triboluminescence. The greatest illuminating value was noted when, in precipitation, the zinc salt was present in excess. The authors tabulate results of experiments on a great variety of samples, prepared in different ways. It is remarked that the results obtained with radium do not in any way concord with those obtained with light. Further confirmation as to the influence of sodium chloride is afforded by the influence of washing the sample. This was found to diminish phosphorescence, whence it is presumed that a useful ingredient is dissolved and lost in the process. It is suggested that the material may be coated with a layer of zinc chloride, which sets up a strain upon the enclosed sulphide rendering it more capable of phosphorescence. J. S. D.

1136. *Distinction between Fluorescence and Phosphorescence.* **S. E. Sheppard.** (Illum. Eng., London, 10. p. 178, June, 1917.)—It is suggested that the time-lag occurring in phosphorescence has a chemical cause and that a real distinction exists between fluorescence, which occurs only during the period of stimulation, and phosphorescence which occurs when the stimulus has ceased [Abs. 780 (1917)]. The former depends conjointly on the chemical composition and constitution of a saturated pure compound: the latter is associated with the presence of stray or unsaturated affinities due to free, usually metallic nuclei of several valency stages, in colloidal or solid solution in the material. This is in accordance with the conclusions of Lecoq de Boisbaudron and Lenard and Klatt, working on alkaline-earth sulphide phosphors. The author illustrates this contention by reference to the behaviour of calcium tungstate which, when prepared in the wet and dried, exhibits neither fluorescence nor phosphorescence, but develops these phenomena when subjected to heat treatment, carried to the sintering-point. It therefore appears that luminous response depends largely on the development of crystalline structure, of which several examples are given. J. S. D.

1137. *Penetrating Power of X-radiation from a Coolidge Tube.* **E. Rutherford.** (Phil. Mag. 34. pp. 153-162, Sept., 1917.)—This paper contains an account of experiments made to determine the max. penetrating power of the X-rays excited by high-voltages in a Coolidge tube, using lead as the absorbing material. In these experiments the absorption of the X-radiation by lead has been examined over a very much wider range of intensity and of thickness of absorber than in the original experiments of Rutherford, Barnes and Richardson [Abs. 1417 (1915)].

A description is given of the method of measuring the absorption coefficients and the voltages applied to the Coolidge tube, the results being tabulated. From a consideration of these results it is observed that: (1) There is not much change in the value of the absorption coefficient (μ) for the end radiations between 79,000 and 144,000 volts, and no observable change in μ between 105,000 volts and 144,000 volts. (2) Between 105,000 and 144,000 volts the radiation is absorbed nearly exponentially with a value of $\mu = 22$. Above 144,000 the absorption is no longer exponential, but the value of μ decreases progressively with increase of thickness of absorbers. This is best shown at 188,000 volts, when the value of μ decreases from 26 to 12 as the thickness of the absorber is increased from 0·7 mm. to 7·0 mm. These results are best explained by taking into account the absorption of rays of different frequencies by lead.

Deductions from the results of Hull and Rice [Abs. 1249 (1916)], who measured the absorption coefficients of lead for X-rays of different wave-lengths (obtained by reflection from a crystal of rock-salt), lead to the same general conclusions.

The peculiarities of the absorption of X-rays of different frequencies afford a simple explanation of the results obtained by Rutherford, Barnes and Richardson (*loc. cit.*). In their experiments the absorption of the "end-rays" by Al was found unchanged between 142,000 and 175,000 volts after the rays had passed through 2·49 mm. of lead as absorber. The table of results now shows that under these conditions the issuing radiation consisted mainly of the characteristic radiation of lead with a value of $\mu = 22$, and no observable change in the absorption by Al would be expected under the experimental conditions. A table of results is also given for the absorption by Al of the end radiation after passing through iron. The corresponding values of μ were found to be higher if lead was used as initial absorber instead of iron.

The observations of the absorption of X-rays in Al and lead throw important light on the question of the probable wave-lengths of the penetrating γ-rays from radio-active substances. The following table is instructive—

Voltages (volts).	Wave-length in Å.U. λ.	Mass Absorption Coefft. μ/ρ	
		in Al.	in Lead.
84,000	0·147	0·154	1·50
102,000	0·122	—	3·00
144,000	0·086	0·11	—
196,000	0·063	—	0·75
Gamma Rays from RaC	?	0·026	0·042

The significance of the values included in this table is fully discussed. It is clear that the wave-lengths of the very penetrating γ-rays are at least three times, and may be ten times shorter than rays which correspond to 200,000 volts, *i.e.* they correspond to waves generated by voltages between 600,000 and 2,000,000 volts, and thus lie between 0·02 and 0·007 Å.U. It is thus clear that the γ-rays from RaC consist mainly of waves of about 1/100 the wave-length of the soft γ-rays from RaB, and are of considerably shorter wave-length than any so far observed in an X-ray tube, with the highest voltages yet attainable in practice. The above deductions are confirmed by the results of Rutherford and Robinson's measurements [Abs. 251 (1914)] on the energy of β-rays from RaC. Voltages varying mainly from 500,000 to 2,102,000 are necessary to account for the observed energies of these β-rays. This is about the same range of voltage estimated to excite the γ-rays, from considerations of absorption of X-rays and γ-rays by Al and lead.

The paper concludes with a short discussion of the bearing of these results on the quantum relation $E = h\nu$, it being pointed out that the groups of β-rays are due to the transformation of γ-rays in *single*, and not *multiple* quanta.

Unsuccessful attempts have been made to measure the wave-lengths, by crystal reflection, of these extremely short γ-rays. A. B. W.

1138. *X-ray Analysis of the Crystal-structure of Rutile and Cassiterite.* **C. M. Williams.** (Roy. Soc., Proc. 93. pp. 418–427, Aug. 1, 1917.)—The method employed in this investigation is essentially that of Bragg, in which a narrow beam of monochromatic X-rays (rhodium rays) is allowed to fall on the various faces of the crystals, mounted on a spectrometer table so arranged that its axis of rotation passes through the face of the crystal.

Rutile (TiO_2) and cassiterite (SiO_2), with which is usually classed zircon ($ZrSiO_4$) crystallise in the holohedral class of the tetragonal system. A comparison of the spacings of the three chief planes gives—

(*a*) Rutile......................	$d_{100} : d_{001} : d_{110} :: 1 : 0·325 : 0·717$
(*b*) Cassiterite	$d_{100} : d_{001} : d_{110} :: 1 : 0·32 : 0·677$

It is noticeable that the spacing of the 001 planes is half what is to be expected from crystal data. The table of results also indicated that the spacing of the atoms in cassiterite is greater than that for rutile: the crystal is built on a larger scale. This is in agreement with the Theory of Molecular Volumes.

From the above observations, in conjunction with measurements of relative intensities of the spectrum lines, models of the crystal structure of these crystals are constructed. The model possesses the full symmetry of the holohedral class of the tetragonal system, and has a tetragonal screw-axis. Both the 110 and 100 planes are indicated as cleavage planes.

The paper concludes with a note on Vegard's work on the same crystals [Abs. 1041 (1916)]. A. B. W.

1139. *Composition of X-rays from Various Metals.* **G. W. C. Kaye.** (Roy. Soc., Proc. 93. pp. 427–442, Aug. 1, 1917.)—In a previous paper [Abs. 457 (1909)] the author described experiments on the X-rays emitted by a variety of metals when used as antikathodes in an X-ray bulb. Among the results established was the homogeneity of a large proportion of the X-rays when the bulb was very "soft." The absorption curves of the several homogeneous radiations revealed their identities with the characteristic "secondary" radiations which Barkla and Sadler had then recently discovered. The experiments now described are an extension of the above, and were carried out just prior to the war. The author's military duties have prevented the continuation of the work. The paper contains a large number of "absorption curves," analysing the various X-radiations after passing through various thicknesses of metal screens. The results are summarised as follows:—"The X-rays from a bulb excited by low voltages (10,000 to 50,000 volts) are rich in the characteristic radiation of the antikathode. In the case of iron, nickel, and copper the amount of K-radiation lies between 80 and 90 %. In the case of platinum the proportion of L-radiation is from 40 to 60 %. Evidence of characteristic radiation softer than the K- and L-radiation has been obtained." A. B. W.

1140. *X-ray Interference produced by Irregularly Orientated Particles.* III. *Constitution of Graphite and Amorphous Carbon.* **P. Debye** and **P. Scherrer.** (Phys. Zeits. 18. pp. 291–301, July 1, 1917.)—This paper describes an interesting and important investigation on the arrangement of atoms in the molecules of the various modifications of carbon, namely: diamond, graphite, and amorphous carbon. The principal methods of X-ray crystal analysis are outlined, viz., (*a*) v. Laue's method in which a narrow pencil of X-rays is passed through a thin slab of the crystal, (*b*) Bragg's method in which a beam of X-rays of known wave-length is reflected from the various faces of a crystal, and (*c*) the method developed by the authors [see Abs. 1180 (1916)] in which a cylinder made up of powdered "crystals" (or even "amorphous" substance) is "radiated" by homogeneous X-rays.

The measurements made by Bragg [Abs. 87 (1914)] have definitely established the form of the space-lattice in the case of diamond.

Different varieties of graphite and amorphous carbon have been examined by the authors. Four varieties of graphite were powdered and pressed into rods of 1 mm. diam. and 10 cm. length. These rods were placed inside the cylindrical camera (described in earlier papers) and radiated by copper K-radiation ($\gamma = 0{\cdot}55 \times 10^{-8}$ cm.). The same procedure was adopted with amorphous carbon.

It is well known that graphite is crystalline, but different investigators are in wide disagreement as to the class of crystal to which it belongs. Thus Kenngott states it to be trigonal, Nordenskjöld monoclinic, Sjögren hexagonal, and so on. Ewald (Bayer. Akad. Wiss., Ber. p. 325, 1914) examining graphite by v. Laue's method classes it in the hexagonal system. Jaeger deduces from Ewald's photographs that graphite crystallises in the trigonal system, not in the hexagonal as stated by Ewald.

Debye and Sherrer criticise the methods employed in the cases to which reference has just been made, and proceed to give the results of their own investigations. They give a table of angles of reflection and relative intensities of the various lines occurring in their photographs from which they deduce that *the graphite crystal belongs to the rhombic system.* Dimensions are given of the sides of the elementary lattice and the angles between the various faces.

It is interesting to note here that Bragg's measurements of the grating space for the 111 plane of graphite lead to a value $3{\cdot}42 \times 10^{-8}$ cm. (obtained by reflecting X-rays from a large plate of graphite), whilst the authors obtain, by the "powder" method, a value $3{\cdot}41 \times 10^{-8}$ cm., in excellent agreement.

The 111 plane is that along which graphite is most easily split. From measurements of the relative intensities of the various lines in the photographs it is shown that graphite consists of a succession of layers of carbon atoms at a distance of $3{\cdot}41 \times 10^{-8}$ cm. apart. In each of these layers the carbon atoms are arranged at the corners of regular hexagons (length of side $= 1{\cdot}45 \times 10^{-8}$ cm.). In successive planes the carbon atoms do not lie vertically over one another. Starting from one corner of a hexagon, and passing through the unoccupied centre of two hexagons (in the successive layers) the corner of another hexagon is encountered. In the fourth stage this lattice is compared with that obtained by Bragg for diamond (cubic). It is shown diagrammatically that the horizontal projections (with the diagonals of cube or rhomboid perpendicular) are identical—the atoms being arranged in regular hexagons.

Comparing the lengths of the diagonals in the elementary parallelepipeds for diamond and graphite—for diamond, Bragg gives $6{\cdot}12 \times 10^{-8}$ cm. and for graphite the authors find $10{\cdot}22 \times 10^{-8}$ cm.—the ratio has the value 0·598, whilst the ratio of the densities of diamond and graphite is 0·62. Consequently the graphite model may be considered as a diamond model with a dilation along a diagonal (in proportion to the densities). Employing this space-lattice, the observations of Ewald and others are reconciled.

In graphite, then, each carbon atom has three equally powerful valencies binding the carbon atoms together in parallel planes (111 planes); in addition these carbon atoms may exhibit a fourth, but considerably less powerful valency. In contrast to this, diamond has all four valencies equally strong: every carbon atom in this case, has four neighbours which are equidistant and symmetrically placed.

In the case of amorphous carbon the following specimens have been examined: Carbon obtained by the charring of sugar and glue; from burnt acetylene, napthalene, and petroleum; from sugar treated with conc. H_2SO_4; retort carbon, and anthracite. In all cases the X-ray photographs are the same and prove definitely the existence of *a characteristic carbon molecule* in all these specimens of amorphous carbons. The photographs show very broad maxima and minima, but the lines correspond in position and relative intensity with those of graphite. They show indisputably that *graphite and amorphous carbon are not essentially different.*

Thus the authors conclude that there exist only *two* modifications of carbon, namely diamond and graphite.

The paper closes with a discussion of the chemical significance of the results obtained. A. B. W.

RADIO-ACTIVITY.

1141. *Attempt to Separate the Isotopic Forms of Lead by Fractional Crystallisation.* **T. W. Richards** and **N. F. Hall.** (Am. Chem. Soc., J. 39. pp. 531–541, April, 1917. Nat. Acad. Sci., Proc. 3. pp. 339–345, May, 1917. Chem. News, 115. pp. 281–283, June 15, and pp. 294–296, June 22, 1917.)—Lead from Australian carnotite (believed to contain about 1 part of ordinary lead to 3 parts of RaG, with a mere trace of RaB) has been fractionally crystallised over 1000 times as nitrate, and the end-fractions purified. The atomic weights of the samples so obtained from the crystal and the mother-liquor ends of the series, respectively, agreed within the experimental error of 6 parts in 100,000. The β-ray activities agreed within the experimental error of 1 %. These observations indicate that the nitrates of RaD and lead on the one hand and RaB and lead on the other hand could hardly be separated, if at all, by less than 100,000 crystallisations.

The outcome gives strong experimental support for the hypothesis that isotopes are really inseparable by any such process as crystallisation.

L. H. W.

1142. *Origin of Fast β-rays.* **H. T. Wolff.** (Ann. d. Physik, 52. 6. pp. 631–648, July 17, 1917.)—A mathematical paper divided into three sections. In the first section electrostatic and electrodynamic formulæ, necessary to the succeeding sections, are deduced. In the second part of the paper it is demonstrated that an electron, eventually to become one of the fastest β-rays, describes a circular orbit around a central positive core, with a velocity almost equal to the velocity of light (viz., max. velocity $= 0{\cdot}998c$). The equilibrium conditions for β-particles in the core are shown to be in agreement with Bohr's quantum law. In the third section of the paper energy relations for the emission of β-rays are considered, and the mass-variation of atoms is discussed with regard to the principles of relativity. The magnetic effects in the neighbourhood of the atom-core are touched upon. A. B. W.

HEAT.

1143. *The Dilatation of Solid Bodies by Heat.* **H. A. Lorentz.** (K. Akad. Amsterdam, Proc. 19. pp. 1324–1341, 1917.)—When in the theory of specific heat the idea had been worked out that the heat motion of solid bodies consists in vibrations of the particles under the influence of the same forces that give rise to the phenomena of elasticity, Debye then successfully attacked the problem of thermal dilatation, and in his theory, which has been further developed by M. J. M. van Everdingen, it is shown that this phenomenon may be accounted for in a satisfactory way by adding, in the expression for the potential energy of the body, terms which are of the third order with respect to the displacements of the particles. In the present paper considerations similar to those of Debye and van Everdingen are presented in a form that is perhaps somewhat simpler. Numerous examples are examined in the light of the mathematical formulæ deduced. While the phenomena discussed in the paper are chiefly determined by the change of the elastic constants caused by a previous deformation, there are also examples given which are independent of this change. H. H. Ho.

1144. *Dilatability of Argon and Neon. Internal Pressure in Monatomic Gases.* **A. Leduc.** (Comptes Rendus, 164. pp. 1003–1005, June 25, 1917.)—The author first describes certain modifications made in his apparatus, which has already been described [see Annales de Chim. et de Phys. 7e ser. vol. 15. p. 62 *et seq.*], for the study of gas compressibility between 1 and 5 atmos., which render it suitable for the determination of dilatation coefficients at constant volume. The dilatability of the containing vessel is determined by means of the weight-thermometer method. For neon between 5·47° and 29·07° the coefficient is 3664×10^{-6}, and for argon between 11·95° and 31·87° it is 3669×10^{-6}. The degree of accuracy of the results is discussed at some length since the coefficient for neon is very nearly that of the perfect gas. These figures are shown to serve as a further justification for the hypothesis that the internal pressures within monatomic gases are proportional to the squares of the molecular weights. H. H. Ho.

1145. *Specific Heat of Air at 60° and 1–300 Atmospheres.* **L. Holborn** and **M. Jakob.** (Zeits. Vereines Deutsch. Ing. 61. pp. 146–147, Feb. 17, 1917. Comm. from the Physikal.-Techn. Reichsanstalt.)—The experiments up to 200 atmos. pressure [Abs. 866 (1915)] have been extended up to 300 atmos., and as a result the most probable value of the specific heat at 59·5° C. and 300 atmos. is found to be $c_p = 0{\cdot}3026$. The expirical formula previously given [*loc. cit.*] is now altered to $10^4 c_p = 2414 + 2{\cdot}86p + 0{\cdot}0005p^2 - 0{\cdot}0000106p^3$.

L. H. W.

1146. *On the Specific Heat of Fluids maintained at the State of Saturation.* **E. Ariès.** (Comptes Rendus, 164. pp. 986–991, June 25, 1917.)—The entropy S of a fluid maintained at the state of saturation is, like the tension P which the fluid exercises and the volume v it occupies, a function of the temperature only. By taking the volume as abscissa and the pressure as ordinate, the cycle of transformation which the body undergoes may be represented by a curve known as the curve of saturation. This curve opens out the question of the specific heat M defined by the general formula $M = T \, . \, \partial S/\partial T$. The specific heat of a saturated liquid is known to be a positive quantity, but data concerning the sign of the specific heat of a saturated vapour at different temperatures are very inadequate and obscure. Combes, Dupré, and others, from a study of specific-heat variations with temperature for water, carbon disulphide, acetone, benzene, chloroform, carbon tetrachloride, alcohol, and ether, state that this coefficient is negative at sufficiently low temperatures, increases with temperature, undergoes inversion and remains positive up to the critical temperature. At temperatures in the neighbourhood of absolute zero, however, very few data are available. The author believes that a more complete and rigorous application of thermodynamic principles will throw light on these obscure points, and the present paper is an investigation of the subject on these lines. The following hypotheses concerning the saturated state, which have received experimental support, are assumed: (*a*) As the temperature increases from absolute zero to the critical temperature, the density of the liquid decreases, and the density of the vapour grows without intermission from zero, the two densities tending rapidly towards equality near the critical state. (*b*) In the neighbourhood of the critical temperature, the specific heat of a saturated vapour is positive, but becomes negative at a lower temperature. This is the conclusion arrived at by earlier investigators.

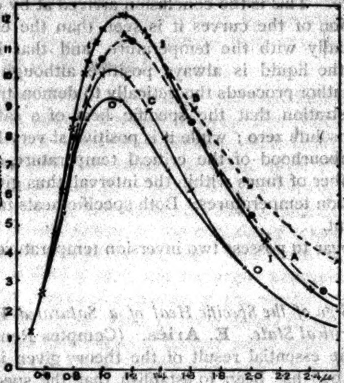
By an inspection of the curves it is seen than the entropy of the liquid increases continually with the temperature, and that in consequence the specific heat of the liquid is always positive although at absolute zero it vanishes, as the author proceeds theoretically to demonstrate. It is shown in the same demonstration that the specific heat of a saturated vapour also vanishes at the absolute zero; while it is positive at very low temperatures as also in the neighbourhood of the critical temperature, although it changes sign an even number of times within the interval, thus giving rise to an equal number of inversion temperatures. Both specific heats take a common value at the critical point.

All bodies appear to possess two inversion temperatures, and two only.

H. H. Ho.

1147. *On the Sign of the Specific Heat of a Saturated Vapour in the Neighbourhood of the Critical State.* **E. Ariès.** (Comptes Rendus, 165. pp. 51–54, July 9, 1917.)—The essential result of the theory given in a previous paper [see preceding Abs.] has been to establish that the specific heat of a fluid (liquid or vapour) is positive at very low temperatures and tends to vanish at absolute zero. To develop the consequences of this theory for more elevated temperatures, the assumption has been made that the specific heat of a saturated vapour is positive in the neighbourhood of the critical state. The reasons for this assumption have been given previously, although its validity is still open to question. Mathias, Duhem, and Raveau held that the specific heat of a saturated vapour became infinite, and negative, at the critical point. It has been demonstrated that this specific heat tends towards negative infinity as the vapour approaches the critical state, but the angular coefficient $\partial P/\partial T$ of the vapour-tension curve referred to the axes of temperature and tension preserves a finite value different from zero even at the critical temperature. This opens up a discussion of the question of the validity of the above opinion with respect to an infinite negative specific heat, and whether the sign be positive or negative in the neighbourhood of the critical state cannot be decided on theoretical grounds alone, but necessitates experimental data. The author points out the delicate character of previous experimental work in this field, and the liability of calculations based upon the data being inaccurate. He then expresses the opinion that the problem might be attacked in a more simple and direct way, inasmuch as it seems unnecessary to operate in the immediate neighbourhood of the critical state where experimental work is so difficult to perform, but to search for inversion temperatures which should be well removed from the critical point. The method would be to take a saturated vapour at a temperature well below the critical, but above the anticipated inversion temperature, and submit it to a sudden and prolonged expansion. If the specific heat be negative, this sensibly adiabatic operation will have for primary effect a condensation of vapour which after attaining a maximum will finish by disappearing completely at a temperature lower than the inversion point. If the specific heat be positive, then the effect of adiabatic expansion will be to cause any traces of liquid to disappear rapidly and to superheat the vapour. By a series of approximations the inversion temperatures may be established. **H. H. Ho.**

1148. *Emissivity of Straight and Helical Filaments of Tungsten.* **W. W. Coblentz.** (Bureau of Standards, Bull. 14. pp. 115–181 [Sci. Papers No. 300], 1917.)—Describes an investigation of the energy distribution in the radiation



from the inside and outside of the turn of a helically wound tungsten filament in an atmosphere of nitrogen. The intensity of the radiation from within the turn of the helix is from 90 to 100 % greater than from a similar area on the outside of the turn. This is accounted for on the basis of multiple reflection within the helix. This modifies the quality of the light so that it is redder than the light from the outside of the turn. There is no indication that the temperature within the helix is higher than on the outside of the turn. A difference in temperature of 200 deg. would be required to account for the observed difference in brightness of 90 %, whereas the pyrometric, thermal conductivity, and other measurements place this temperature-difference at less than 5 deg. The observed infra-red measurements on the radiation from within the helix and the computed values (obtained on the basis of multiple reflection and the reflectivity of tungsten) are in close agreement. This is further evidence that the phenomenon is the result of multiple reflection. Tests were made with a Nicol prism, which showed that the light from some parts of the inside of the filament is highly polarised, indicating that the quality of the light is quite different from that of a black body. The infra-red energy measurements also indicate that the quality of

the radiation differs from that of a black body. In fact it is found that although the quality of the radiation has been modified by multiple reflection within the helix, it is not sufficiently similar to that of black-body radiation to permit of its use in exact temperature measurements by sighting an optical pyrometer within the turns of the helix. Computations of the radiation of tungsten indicate that, as found in previous investigations [see Abs. 860 [1909]], the Wien equation is not applicable to the radiation from tungsten. The actual energy-distribution curves found for the inside and outside of the helical filament are shown in the Fig. by curves I and O respectively.
J. W. T. W.

1149. *The Measurement of Cryoscopic Constants at Elevated Temperatures.* **J. H. Mathews.** (Am. Chem. Soc., J. 39. pp. 1125–1133, June, 1917.)—The author describes an apparatus for the accurate determination of cryoscopic data at elevated temperatures. The freezing-point tube, surrounded by a larger tube to serve as an air-jacket, is placed in the neck of a specially designed flask fitted with reflux condenser and attached to a manometer. In this flask a suitable heating liquid is placed and kept boiling under a definite pressure. The freezing-point tube is thereby kept surrounded by vapour and an efficient heating jacket thus obtained. The author has tested his apparatus by experiments on the freezing-point of solutions of anthracene in naphthalene, anthracene in acetanilide, anthracene in benzoic acid, and of anthracene in cinnamic acid. He concludes that the accuracy of the method seems to be limited by the accuracy with which temperatures can be read by the thermometer. Work on the same lines, but with the aid of a Pt-resistance thermometer, is contemplated. A. F.

1150. *The Thermodynamic Constants of Ammonia.* I. *Heat-capacity of Liquid Ammonia.* **F. G. Keyes** and **H. A. Babcock.** (Am. Chem. Soc., J. 39. pp. 1524–1537, Aug., 1917.)—The authors have determined the heat capacity of liquid ammonia by the method of mixtures, strictly comparable measurements being made with a substance of known heat capacity. The containers for the two substances were made identical, and the quantity of the reference substance used was so adjusted that the same temperature-change was obtained in the calorimeter as with the substance under examination. Water was used as the reference substance and the values of its heat capacity as determined by Bousfield have been employed in the calculations. The mean specific heat capacity of liquid ammonia was measured for the temperature intervals 0°–20°, and 20°–50°. Its value expressed in 15° calories is 1·152 between 0° and 20°, and 1·172 between 20° and 50°. The equation for the true specific heat capacity obtained from these data (assuming it to be a linear function of the temperature), is $C_s = 1·144 + 0·0008t$. A. F.

1151. *Physical Constants of Chlorine.* **M. Pellaton.** (Journ. Chim. Phys. 13. pp. 426–464, Dec., 1915.) — Experiments by Jaquerod and Tourpaïan made in the same laboratory (University of Neuchâtel), having yielded a weight of 3·214 gm. per 1 litre of Cl which would give the atomic weight of 35·28 (instead of 35·46), the author redetermined the constants. The chlorine was generated by heating auric chloride. The experiments and apparatus (glass) are described in detail and the results discussed. Vapour pressures were determined at −78·9°, −33·8°, −21·2°, and above 0° up to the critical temperature which is found to be 144°; the critical pressure is 76·1 atmos., the critical density (not previously determined) 0·573 or $v_k = 1·745$. The formulæ found for the densities of the liquid and of the saturated vapour are of the same type. The ordinary boiling-point is —34·5°. The heat of vaporisation is calculated from the vapour pressure after Clapeyron. On the whole chlorine behaves like a normal substance. It varies little with the temperature and at the critical point $f = T_c dp/p_c \,.\, dT_c = 6·56$; the ratio of the critical density to the theoretical density is 3·685($CO_2 = 3·59$); the Trouton constant is 20·67, nearly normal; the vapour tension curve is normal. There is thus no evidence of polymerisation, and the fact that the weight per litre yields too small an atomic weight, would be against association; yet there remains an uncertainty requiring further investigation. The author also determined the dissociation pressure of $AuCl_3$ between 140° and 260°; it was found to increase from 4·5 to 981 mm. within these limits. H. B.

1152. *Partial Separation by Thermal Diffusion of Gases of Equal Molecular Weight.* **S. Chapman.** (Phil. Mag. 34. pp. 146–151, Aug., 1917.)—If a temperature gradient be applied to a mixture of two gases diffusion takes place, this being independent of non-uniformity of composition, or of the action of external forces [see Abs. 794 (1916); 147 (1917)]. Experiments in confirmation of this have already been published [Abs. 518 (1917)]. This "thermal diffusion" effect should be greatest when the gases are mixed in equal proportions by volume, and when the masses and diameters of the gas molecules are most unequal. It vanishes altogether for Maxwellian molecules, *i.e.* for point centres of force varying inversely as the fifth power of the distance; also when the masses and diameters (or laws of interaction) of the two sets of molecules are alike.

Thermal diffusion offers a method of partial separation of two gases electrically neutral and *of equal molecular weight*, provided the diameters of the molecules or laws of interaction are not identical. If the molecular masses are unequal and the diameters equal the heavier gas diffuses towards the cooler regions. When the masses are equal but the diameters unequal the larger molecules diffuse in that direction. Formulæ are given together with numerical examples in illustration. In the case of a mixture of C_2H_4 and N_2 of approximately equal molecular weights, the molecular radii, deduced from the coefficients of viscosity on the hypothesis that the molecules are rigid elastic spheres, are as 2·39 : 1·84. If the mixture be placed in a tube with its two ends at temperatures 200° and 544° abs. the percentage difference of composition in the steady state would be 1·22 %. By successive operations of thermal diffusion a very appreciable difference of relative proportions could be produced in the mixture. Whether this method could be applied to the separation of radio-active products of nearly equal molecular weight the author is not prepared to say. T. B.

1153. *Thermodynamic Cycles with variable Specific Heat of Working Substance.* **W. J. Walker.** (Phil. Mag. 34. pp. 168–174, Sept., 1917.)—The paper deals with those thermodynamic cycles which are of special interest in internal-combustion engineering science. Assuming that the variations of the two specific heats of a gas with temperature are given by linear formulæ and that their difference is constant at all temperatures the author obtains, by an extension of Lees's method of analysis [Abs. 167B (1915)], a closely approximate and fairly simple expression for the thermal efficiency of the dual combustion cycle (*i.e.* one in which the heat is supplied partly at constant volume and partly at constant pressure and is rejected at constant volume). From this expression the efficiencies of the constant-volume and constant-pressure cycles can be deduced at once, *e.g.* by supposing that the pressures at the two ends of the constant-volume line are equal this stage disappears and the constant-pressure cycle is obtained. In conclusion, an interesting relationship is pointed out between the efficiency expressions for these cycles as given, and that for the Carnot or constant-temperature cycle. D. O. W.

1154. *Some Vapour Pressures at Low Temperatures.* **G. A. Burrell** and **I. W. Robertson.** (Bureau of Mines, Techn. Paper No. 142. [82 pp.], Washington, 1916.)—The substance under test is confined in a glass bulb, joined above on one side to a Töpler pump and on the other to a mercury manometer. The bulb is immersed in a Dewar flask charged with liquid casing-head gasoline, which is cooled by passing liquid air into an open tube, dipping into the bath; the arrangement is that of Henning's thermostat [see Abs. 826 (1913)] and pentane thermometers were also used, as in the Reichsanstalt, reading down to −195° C. The gasoline turned into a jelly at −175°. Vapour pressures were determined at temperatures below the normal boiling-point and at pressures ranging from 760 mm. down to 1 mm. of mercury, the substances being specially purified partly by fractional distillation. The calibration is described, and tables of vapour pressures are given for ethylene (boiling-point re-determined, 169·2° abs.), ethane, acetylene, isobutane, propane, propylene, normal butane, ammonia, nitrous oxide (boiling-point re-determined, −88·7° C.), sulphur dioxide. Vapour-pressure curves are calculated from the tables after Nernst. In most cases the range of the determinations is much greater than in previous work. H. B.

1155. *Calculation of the Constants of Planck's Radiation Equation: An Extension of the Theory of Least Squares.* **H. M. Roeser.** (Bureau of Standards, Bull. 14. pp. 237–253 [Sci. Papers, No. 304], 1917.)—During the past few years several methods have been proposed for determining from experimental measurements the constants of Planck's equation for the distribution of energy in the spectrum of a uniformly heated enclosure or black body. The equation is $E = c_1\lambda^{-5}(e^{c_2/\lambda\theta} - 1)^{-1}$, where E is a measure of the energy, λ the wave-length, θ the absolute temperature, c_1 a constant depending on the units in which E is measured and giving the scale of ordinates, and c_2 a constant which affects the shape of the curve and is sometimes called the "constant of spectral radiation." On account of the ease of elimination from computations and its minor importance in indicating the actual distribution of energy, passing mention is usually deemed sufficient for c_1. Several methods have been offered for the computation of the more important c_2 from observed data on E and λ at constant temperature or E and θ at constant wave-length. Recent discussions have been devoted to observations at constant temperature, the curve in this case being called an "isothermal," and the methods of solution differ mainly in the manner of combining observations and in the use of correction terms to the transcendental expression for c_2 in terms of the other magnitudes involved. Some variations have appeared in the results given by these different methods. Van Orstrand has suggested as a remedy a solution by least squares, and the present paper contains an attempt to utilise this suggestion. A method of attack is indicated and a least-square solution for the constants made, using some of the data that have been employed in the past to determine c_2 by other methods. Theoretical reasons why the results of some of the previous investigations differ are included. A least-square reduction of a set of observations of the Planck radiation-equation type has been effected by taking logarithms of both sides and assigning proper weights to the transformed equations. The method of assigning these weights has been given in a general form that can be adapted to any scheme of transformation. How to combine and weight separate computations for c_2 by the two-point method so as to yield a value that agrees with the least-square value has been shown. A numerical demonstration is given that the proposed system of weights applied to an arbitrarily selected set of two-point calculations leads to a result which approximates the least-square value better than the simple mean of the set. Numerous tables are included in the paper. H. H. Ho.

1156. *Influence of Accidental Deviations of Density on the Equation of State.* **L. S. Ornstein** and **F. Zernike.** (K. Akad. Amsterdam, Proc. 19. pp. 1812–1815, 1917.)—From their article in the "Encyclopädie der mathematischen Wissenschaften" the following statement by Onnes and Keesom is quoted :—"On approaching the critical point (liquid-gas) density-differences appear, which, on the Boltzmann-Gibbs' principles are due to rising compressibility. On developing the equation of state for the neighbourhood of the critical point, new terms arise which possess a special significance in this zone, while having no further value in zones beyond. During a gradual displacement or distortion, affecting the whole diagram, the terms in the equation of state referred to above point to the conclusion that the properties in the critical zone deviate in an observable manner from those which should be expected by interpolation between states lying in the neighbourhood of the critical state." Onnes and Keesom assert that they have found deviations pointing to such-like cases, and they have tried to account for the special phenomena at the critical point by adding a function of disturbance to the equation of state which takes specially large values at the critical point. In the present contribution the authors attempt to establish that there can be no question about a function of disturbance caused by the accidental deviations of density. They derive a formula which shows that if deviations of density are taken into account, a new term appears in the equation of state, which, however, is not equivalent to the function of disturbance evolved by Onnes and Keesom. The special character of the new function in the neighbourhood of the critical point causing the clustering tendency there to become very strong, consists in the fact that this function gets perceptible values for points far outside the sphere of action. The authors deduce that the abnormal character stated by Onnes and Keesom cannot be explained by a function of disturbance as a consequent of the accidental deviations. H. H. Ho.

1157. *On the Dieterici Equation of State.* **F. H. MacDougall.** (Am. Chem. Soc., J. 39. pp. 1229–1235, June, 1917.)—In a recent article [see Abs. 584 (1916)] the author has discussed the Dieterici equation of state, $p = \mathrm{RT}e^{-a/v\mathrm{RT}}/(v-b)$, and applied it to a number of substances including isopentane, carbon dioxide, and hydrogen. Various methods were developed for calculating the values of the constants a and b, below, at, and above the critical temperature, and formulæ were deduced connecting the pressure of saturated vapour and the latent heat of vaporisation with the densities of liquid and saturated vapour. In the present paper the author brings forward an additional method of calculating "a" and urges strongly the advantages, both theoretical and practical, which the Dieterici equation has over any equation of the van der Waals type. The author opines that the chief cause of the failure of van der Waals' equation to be much more than qualitative in its application, is to be sought in the form of the function assumed for the "cohesive" or "internal" pressure. This view is confirmed by a careful study of Boltzmann's results in his kinetic theory of gases. The latter leads to the conclusion that a and b may be both volume and temperature functions, and the author determines their nature, using the Dieterici equation as a basis. He finds that *b* increases as the critical temperature is approached, reaches a maximum and then decreases, while *a* always decreases with rise in temperature. Bakker's work on surface films is next reviewed, and followed by a reference list of equations. The heat of vaporisation is dealt with and the inference drawn that *b* does vary slightly with the volume when the latter is that of the substance in the liquid state. The paper concludes with an account of the new method for calculating *a*, and the values obtained are compared in a table with those calculated by other methods. H. H. Ho.

1168. *Contributions to the Kinetic Theory of Solids.* I. *The Thermal Pressure of Isotropic Solids.* **L. S. Ornstein** and **F. Zernike.** (K. Akad. Amsterdam, Proc. 19. pp. 1289–1294, 1917.)—P. Debye has developed a theory of the equation of state of solid matter, in which he assumes as a physical principle that the forces between the molecules in solid matter are not quasi-elastic, but depend also on higher powers of the deformations. He points out that only this principle enables us to understand the expansion of solid matter which gains energy under constant pressure. This assumption enables him to give a deduction of the Grüneisen theorem about the connection between the coefficient of expansion and the specific heat. Debye calculates the free energy of a solid body with the help of a canonical ensemble, using the method of normal vibrations, and introducing from the outset the hypothesis of energy-quanta. The present paper indicates another method of evolving the equation of state with the aid of the physical principles of Debye. The quantum-theory is applied to the final result if it is required for low temperatures. Since Debye has introduced the replacement of the space-lattice of molecules in the calculations, and Born has verified the validity of this artifice, the present author in considering the isotropic body uses the continuum as a limiting case. For explanation he treats the case of a row of points, and performs the transition to a continuous bar. The method consists in determining the thermal pressure, *i.e.* the pressure that is required to keep constant the volume of a solid body which is gaining heat. First a row of *n* equidistant points is investigated, and this is followed by an approximation to a continuum whereby a bar is considered in which the elastic qualities depart from Hooke's law. The same results are then obtained by applying the method of normal vibrations. Finally, the thermal pressure of an isotropic solid body is determined. The result obtained agrees with the expression found by van Everdingen.

II. *The unimpeded spreading of Heat even in Case of Deviations from Hooke's Law.* (K. Akad. Amsterdam, Proc. 19. pp. 1295–1304, 1917.)—In a supplement to his lecture on the equation of state of the solid body, Debye has endeavoured to make a qualitative calculation of the coefficient of conduction of heat. The estimations, however, are only approximate, and Debye points out that they should serve as a first orientation only. The present authors now attempt to obtain an accurate calculation of the conduction of heat, while adopting a modified procedure. Debye's principle is that in an ideal solid body, *i.e.* a solid for which the elastic equations would be linear, various progressive waves may exist independently of each other, like the electromagnetic waves in a field of radiation. This implies that a heat-motion occurring on one side of the solid spreads unimpededly through the solid, so that the density of energy becomes equal in all parts of the solid. If the solid is in a stationary state, the temperature will thus be everywhere the same, even if continually a current of energy moves through the solid in a definite direction. Hence Debye emphasises this dictum: The coefficient of heat conduction of the ideal solid body is infinitely great. The author opines that in several regards it is preferable to formulate the rule in this way: The ideal solid body does not show any resistance to heat. That a real solid body does show resistance to heat, Debye ascribes to the fact that the elastic equations are not perfectly linear. Therefore various normal vibrations cannot be strictly superposed, and it is conceivable that waves running in different directions, so to say, oppose each other. Debye has succeeded in deducing indirectly a scattering, and, consequently, a suppression, of the running waves. The present authors in their endeavour to state more directly the connection between resistance of heat and non-linear terms of the elastic equations of motion, have failed. They have formulated the problem, however, because of its importance on other grounds. Where Debye introduced the great simplification of considering longitudinal waves only, for a more strict calculation only such waves as run in a special direction should be examined. In the case of the longitudinal waves of a thin bar, the movement may be represented by a superposition of normal-vibrations, and it is necessary to suppose hereby a special statistical distribution of the energy over the different vibrations. At a high temperature equipartition may be assumed at first sight without troubling about how it occurs, but it is remarkable that in this case there can be no question of equipartition establishing itself as it occurs in a gas by the collisions, since during the movement the energy of each normal-vibration remains constant, so that any method of division continues to exist permanently. Statistically stated this is: Time-ensemble and microcanonical ensemble are very different from each other, and consequently are not practically equivalent. This difficulty, which is essentially connected with the existence of normal-vibrations of the system, disappears as soon as non-linear terms of higher order are introduced into the equation of motion. When these terms are very small, and this is sufficient, then one may speak of the quasi-normal vibrations of the system, and, during a short interval, these quasi-normal vibrations behave at first approximation like normal-vibrations, but the non-linear terms, however, bring about a slow exchange of energy between the quasi-normal vibrations. The authors record some positive results showing the non-existence of a heat-resistance, even if deviations from Hooke's law appear. They confine themselves to the linear problem, so that it still remains uncertain whether the conclusion holds really for 3 dimensions. The latter leads to some principal errors in Debye's calculation, which point to his results not only being merely qualitative but quite illusory in the authors' opinion. It is shown that waves in different directions run over each other without any exchange of energy, and, as a consequence, there is no fall of energy along the bar, *i.e.* no heat-resistance. The final conclusion drawn is that the molecular theory of the heat-resistance still remains entirely open.

III. *The Equation of State of the Isotropic Solid.* (K. Akad. Amsterdam, Proc. 19. pp. 1304–1312, 1917.)—In this section the authors employ the method developed in Part I for the determination of the expansion in order to deduce the equation of state, *i.e.* the connection between the strain and the stress in its dependence on the temperature. Only the simple case has been dealt with in Part I, and a quite analogous deduction is now used to find the stresses of a solid which has been deformed at the absolute zero. The only difference from the former case lies in the fact that by this strain the solid generally departs from exact isotropy, and a more ample calculation is necessary in the case of shearing. It is then shown that the equation of state is to be found by the aid of thermodynamic relations from the specific heat of solid bodies, which latter may be calculated from the formulæ given by Born.

H. H. Ho.

SOUND.

1159. *Simple Vibrations of Air in Pipes and the Dust-figures thus produced.* **G. Schweikert.** (Ann. d. Physik, 52. 4. pp. 333–397, May 10, 1917.)—A mathematical treatment from which the following conclusions are drawn :—(1) By constant ratio (σ) of densities of neighbouring air slices, the linear dimensions of the waves vary with the square of the relative speeds of the two slices. (2) By constant values of the ratio of the densities of the air slices, *i.e.* by unchanged amounts of the same powders, the length of the dust waves (or pitch of the ripples) varies directly as the square of the relative velocities of the air slices. (3) By constant amplitude of vibrations the pitch of the ripples varies inversely as $(1-\sigma)$. [See Abs. 228 (1916).] E. H. B.

1160. "*Wolf-Note*" *on Bowed Instruments.* **J. W. Giltay.** (Phil. Mag. 33. p. 536, June, 1917.)—The author expresses interest in the paper by C. V. Raman on this subject, but does not agree as to the cause of the mute-effect. Raman says "the explanation of the effect of a mute on the tone of the instrument is chiefly to be sought for in the effect of the loads applied on the frequencies of the principal free modes of vibration of the bridge and associated parts of the belly." The present author supposes the change of pitch of the note of maximum resonance of bridge, belly, etc., will be practically the same whether the bridge is loaded at its highest part or as low as possible and near to its left foot. Yet the difference of tone-quality is very large, as was shown by himself and de Haas; in the first case the sound is strongly damped (the ordinary mute-effect), whereas in the second case only a very slight damping of the G-string is noticeable. Further, though the fall of pitch of the resonance note, caused by a mute, might explain an alteration of timbre for those notes whose pitch approaches that of the (lowered) resonance note, it is felt difficult to accept this explanation of the great change of tone-quality of the highest notes on the E-string. [See Abs. 404 (1910) and 1366 (1916).]

E. H. B.

1161. *Thermophone as a Precision Source of Sound.* **H. D. Arnold** and **I. B. Crandall.** (Phys. Rev. 10. pp. 22–38, July, 1917.)—The authors have found that the thermophone, together with a suitable supply of alternating current, can be used very conveniently as a precision source of sound-energy. Since the previously-published material on this electrical-acoustic effect is largely qualitative, the present paper includes a quantitative theory, and shows how the instrument can be adapted to acoustic measurements. A simple form of instrument has a Pt-strip 7×10^{-5} cm. thick; this fits into terminal clamps connecting it with the current leads, the whole being mounted on a fibre base. If used with a pure alternating current $I \sin pt$, the heating effect is proportional to $RI^2 \sin^2 pt = \frac{1}{2}RI^2(1-\cos 2pt)$, so that the acoustic frequency is double the electrical. If it is desired to make the acoustic wave follow the alternating-current wave without introducing the double frequency, resort must be had to a superimposed direct current several times as large as the amplitude of the alternating one. Thus, if a direct current I_0 and an alternating one $I' \sin pt$ are used to heat the strip, the heating effect is proportional to

$$R(I_0 + I' \sin pt)^2 = R(I_0^2 + \tfrac{1}{2}I'^2) + 2RI_0I' \sin pt - \tfrac{1}{2}RI'^2 \cos 2pt.$$

From this it is evident that the double-frequency term can be made negligible by suitable choice of I_0 and I'. The theory of wave propagation from the periodically heated strip is then developed.

An account is next given of experimental tests, the results of which are in substantial accord with the theory. It is claimed that the thermophone is adapted to two classes of service, namely: (*a*) as a precision source of sound at any frequency; (*b*) as a source of sound of known relative loudness at different frequencies throughout the acoustic range. [See Abs. 719 (1915).]

E. H. B.

1162. *Condenser Transmitter for Absolute Measurement of Sound Intensity.* **E. C. Wente.** (Phys. Rev. 10. pp. 39–68, July, 1917.)—A description is given of a portable transmitter, of the electrostatic type, which is specially adapted for measurement of sound intensities over a wide range of frequencies. A theory of the transmitter is developed by which its operation can be predicted from a few simple measurements. The absolute calibration of such an instrument shows its efficiency to be practically uniform for frequencies up to 10,000 cycles per sec.; the results are in accord with theory. When properly calibrated this apparatus can also be used as a precision source of sound. [See preceding Abs.] E. H. B.

1163. *Maintenance of Vibrations by a Periodic Field of Force.* **C. V. Raman** and **A. Dey.** (Phil. Mag. 34. pp. 129–137, Aug., 1917.)—The effect of a periodic field of force on the motion of a body subject to its influence was discussed by one of the present authors [Abs. 1081 (1915)], one of the results of outstanding importance noticed being the series of special relations between the frequency of the field and that of the steady vibration possible under its action. It was shown that the motion is capable of being maintained when its frequency is either equal to, or is 1/2, 1/3, 1/4, 1/5, or 1/6 of the frequency of the field, that is, any submultiple of it, but not when the frequency has any intermediate value. The experimental work and theory published in that paper related to the motion of a system with only one degree of freedom, the period of free vibration of which is determined entirely by the field. The vibrations were those of the armature of a synchronous motor of the attracted-iron type *when not in rotation*, under the influence of the magnetic field due to an intermittent current. Recently, when experimenting with the electrically-maintained vibrations of wires, the authors have noticed certain interesting effects which may be classed with the phenomena referred to above, but which merit separate discussion in view of the fact that the system in this case has a series of free periods of its own, quite independently of the field.

The present investigation relates to the vibrations of a steel wire about 2 m. in length, stretched vertically under an adjustable tension, and subject to the transverse periodic force exerted by an electromagnet placed near some selected point on it. The electromagnet was excited by an intermittent current from a fork-interrupter whose frequency was usually 60 per sec. The forced vibrations (having the same frequency as the intermittent current), which are usually excited in the first instance, when the tension of the wire is adjusted for resonance, are of the same form as those described by Klinkert in a paper on electrically-maintained vibrations [Abs. 1388 (1898)]. It is noticed, however, that when the tension is such that the wire vibrates in two, three, or a larger number of segments, and the electromagnet is not too far away from the wire, *the motion of the usual type first set up is unstable*, and gradually changes form, the nodes ceasing to be points of rest, and the frequency of vibration changes to a value which is a sub-multiple of the frequency of the fork. For instance, if the wire initially divides up into two segments and vibrates with a frequency of 60, its centre, which at first is a node, gradually acquires a very considerable motion, and the frequency of the vibration alters to 30. Similarly, if the wire initially vibrates in three segments, the frequency changes to 20 when the instability sets in: when the initial vibration is in four segments, the frequency changes to either 30 or 15 according as the instability does or does not result in a movement of the centre of the wire, and so on.

To enable the frequency of the field to be compared with that of the motion set up by it, the vibration-curves of some selected point on the wire and of a small style attached to the fork-interrupter are simultaneously recorded on photographic paper. Six records are reproduced. They represent, respectively, cases in which the frequency of the vibration is equal to that of the field and 1/2, 1/3, 1/4, 1/5 and 1/6 of it. Excluding the first, which is of the usual type, these records are typical of those secured at a fairly early stage of the progressive change of vibration-form, the electromagnet being placed at about 1/8 of the length of the wire from one end, and the point of observation being at a similar distance from the other end: the record in each case, which represents the vibration of the wire, shows a strong upper partial having the same frequency as the field.

The paper includes a mathematical theory of the phenomena in question. E. H. B.

1164. *Vibration Frequencies of Elastic Systems.* **M. D. Hersey.** (Washington Acad. Sci., J. 7. pp. 437–445, Aug. 19, 1917.)—This paper deals with the free vibrations of perfectly elastic bodies, damping and forced vibrations being excluded. The purpose is to present the most complete statement, regarding the vibration frequencies of such bodies, which is possible in advance of any knowledge of their geometrical shape. The paper is specially offered to those engaged in acoustics, in the development of time-keeping devices, or in problems of engineering construction where resonance has to be avoided. Others may find the paper suggestive in showing what can be done by combining dimensional with ordinary physical reasoning in cases where either alone would fail. This paper follows the lines of a previous one on "The Stiffness of Elastic Systems" to which it may be regarded as a sequel. [See Abs. 1188 (1916).]

In a special notation the author then derives formulæ for (1) the frequency of a single body, and (2) its change with temperature, (3) the relation of frequency to stiffness, (4) the frequency of a coupled system, (5) its change with temperature.

These expressions are then applied to special cases including (*a*) waves in an infinite elastic plate, (*b*) temperature compensation of ordinary tuning-fork, (*c*) telephone diaphragm, (*d*) balance wheel of watch. E. H. B.

1165. *Just Intonation of Musical Scales.* **G. Sizes.** (Comptes Rendus, 165. pp. 264–267, Aug. 13, 1917.)—Dwells upon the inherent difficulty of attempting to realise in keyed musical instruments the theoretically just intonation. [See Abs. 1178 (1913).] E. H. B.

1166. *Abnormal Propagation of Sound in Air.* **S. Fujiwhara.** (Monthly Weather Rev. 44. pp. 436–439, Aug., 1916.)—Discusses the regions of audibility of volcano explosions on certain theories as to winds at various levels, and the consequent reflections of the sound. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1167. *Magnetisation of Iron, Nickel, and Cobalt by Rotation.* **S. J. Barnett.** (Phys. Rev. 10. pp. 7–21, July, 1917. Paper read before the Am. Physical Soc., Dec., 1916.)—An extension of previous work to other specimens of iron and to cobalt and nickel. The new work described in this paper has been done by the magnetometer method. Diagrams of the important parts of the apparatus are given, also reproductions of actual photographs of it. Every set of observations gave the sign of H/n negative like that of $4\pi m/e$ for an electron. (It was previously shown that the rotation of a body with angular velocity n revs. per sec. is equivalent to putting it in a magnetic field of intensity H, such that $H/n = 4\pi m/e$). The mean magnitude of H/n is in all cases somewhat less than the accepted magnitude of $4\pi m/e$; H/n ranging from $5{\cdot}1$ to $6{\cdot}5 \times 10^{-7}$ e.m. unit against, for $4\pi m/e$, $7{\cdot}1 \times 10^{-7}$ e.m. unit. The investigation must be taken as confirming the above equation both qualitatively and quantitatively on the assumption that only electrons are in orbital revolution in the molecules of all the substances tested. It shows, moreover, that the effect is independent of the size of the body in rotation, which is an implicit requirement of the equation. [See Abs. 1761 (1915) and 550 (1917).] E. H. B.

1168. *Electrodynamics and the Interference Principle.* **K. Uller.** (Phys. Zeits. 18. pp. 347–351, Aug. 1, 1917.)—Mathematical discussion of Hertz's theory and the relativity principle of Einstein. E. H. B.

1169. *Instability of Electrified Liquid Surfaces.* **J. Zeleny.** (Phys. Rev. 10. pp. 1–6, July, 1917.)—In a recent paper [Camb. Phil. Soc., Proc. 18. p. 71, 1915] a brief description was given of the appearance of a liquid surface undergoing disintegration owing to instability arising from an electric charge. The observations recorded were made in connection with some experiments on the electric discharge from liquid surfaces and the work was confined to eye observations, through a microscope, of the surface in question when this was illuminated by the light of a spark from a Leyden jar. Some of the phenomena appeared to be of sufficient interest to warrant the making of a more accurate record of them by the aid of photography, and the present paper deals with a few results which this method has produced. Reference must be made to the paper quoted above for details of the apparatus used. Briefly, the apparatus consisted of a vertical glass tube, 0·92 mm. diam., joined from its upper enlarged end by rubber tubing to a reservoir of the liquid. A drop of liquid at the lower end of the small glass tube was the part under observation. The liquid was charged to several thousand volts from a static machine, and a grounded plate was placed about 2 cm. below the end of the glass tube. Ethyl alcohol was used for nearly all of the experiments inasmuch as water is not a convenient liquid for showing some of the phenomena, because, owing to its high surface tension, the potential at which instability of its surface is first obtained in air at atmospheric pressure is nearly the same as that at which an electric discharge begins. The source of light mostly employed in taking instantaneous pictures of the liquid was a condenser discharge between magnesium electrodes in air. For some of the exposures the spark was passed through mercury vapour at atmospheric pressure as in

C. T. R. Wilson's experiments. When the liquid is unelectrified and the supply reservoir raised until liquid issues from the end of the tube at a certain slow rate, then drops with a diam. larger than that of the tube will form, break off, and fall away. On electrifying the liquid sufficiently and lowering the reservoir to keep the outflow the same as before, the drops will be drawn out into a more or less cylindrical form before they break from the tube. After severance, these cylindrical pieces will coalesce into drops whose diam. may be considerably smaller than that of the glass tube from which they came. When, however, the electrification is increased to a point where the electric force at the surface of the liquid attains a certain limiting value, which depends upon the surface tension of the liquid and the radius of curvature of its surface, then, irrespective of whether or not the liquid pressure is sufficient to force liquid out of the tube, the surface becomes unstable and any slight accidental displacement of the surface results in a rapid increase of that displacement. This condition is first reached at the lower end of the drop where the electric density is greatest. What happens is that the liquid at this place is pulled out into a fine thread which eventually breaks up into minute drops.

A series of photographs are given in the paper illustrating the various experiments performed. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

1170. *Industrial Application of Electrons.* **J. J. Thomson.** (Engineering, 103. pp. 562–563, June 15, 1917. Discourse delivered before the Roy. Inst.)—Deals with the mode of operation of the electronic valve and its applications as amplifier and as generator. L. H. W.

1171. *Effect of the Earth's Curvature on Wireless Telegraphy.* **A. Sommerfeld.** (Jahrb. d. Drahtl. Tele. 12. pp. 2–15, June, 1917.)—The problem of the transmission of signals along the curved surface of the earth has been considered by many authors. This article is mainly concerned with the distances of transmission given by v. Rybczynski [Abs. 1489 (1913)], Nicholson, and Austin. New mathematical approximations are employed, and the expression obtained is compared with the ones given by the authors referred to. The author concludes that the daylight transmission distances can be explained without the aid of a reflection of the waves in the upper layers of the atmosphere, and that the reflection theory may be considered to explain the abnormal and variable transmission obtained at night-time. A. J. M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1172. *Temperature Variation of Electrical Conductivity of Mica.* **H. H. Poole.** (Phil. Mag. 34. pp. 195–204, Sept., 1917.)—In previous experiments on the dielectric constant and electrical conductivity of mica in intense fields, the author found that the conduction current accorded well with the formula $C = aXe^{bX}$, where C is the current density, X the potential gradient, and a and b are constants. It was also then suggested that the occurrence of the exponential term might be connected with a distribution of electronic velocities in accordance with Maxwell's law [see Abs. 1070 (1916)].

The results of the present further experimental work confirm the above formula. For the specimen previously used a was approximately proportional to the 16th power of the absolute temperature over a range from 0° to 47° C., and b was independent of the temperature. For another specimen, a was proportional to the 15·47th power of the absolute temperature from 50·5° to

229·5° C., and *b* independent of the temperature. Although the values of *a* were widely different in the two cases, those of *b* were almost identical. The fact that *b* is independent of temperature does not agree well with the suggestion that the exponential term is due to a distribution of electronic energies in accordance with Maxwell's law. E. H. B.

1173. *Measurement of Small Inductances and Power Losses in Condensers.* **A. Campbell.** (Phys. Soc., Proc. 29. pp. 345–358, Aug., 1917.)—The methods of measurements described are developments of the method of testing transformers described by the author some years ago. They are based on the use of the "elementary pair" consisting of a mutual inductance associated with a resistance. A number of connections are given that are suitable for the measurement of small inductances. Arising out of the discussion of the "elementary pair" it is shown how it may be so dimensioned as to form a transformer, the ratio of current transformation of which is constant for all frequencies and wave-forms. When using leaky condensers in the tests it is possible to compensate for the loss in the condenser, and measure the condenser losses by the addition of an auxiliary closed circuit. Condensers thus compensated may be used together with mutual inductance as previously explained [Abs. 820B (1912)], as wave sifters to suppress a component of any desired frequency in a given circuit. A. J. M.

1174. *Multiple Braun Electrometer.* **E. Békefy.** (Zeits. Instrumentenk. 37. pp. 151–153, July, 1917.)—The author discusses the reasons for the non-linearity of the scale in the ordinary type of Braun electrometer: the scale divisions (for equal voltage-differences) become rapidly smaller for decreasing voltage. Since the explanation depends on the mathematical properties of Coulomb's law, the non-linearity of the scale comes from the $1/r^2$ factor in $K = e_1e_2/r^2$ where r = distance apart of the electric charges). Extending this principle to the case of an electrometer with "*n*" moving plates; in this case the factor $1/r^2$ (for a single moving plate) becomes n^3/r^2 (for "*n*" moving plates). Thus the sensitiveness has been increased n^3 times.

In order to demonstrate the principle, the author has constructed a multi-leaf electroscope which can be used for measuring small potential differences. A. B. W.

1175. *Experiments with Photoelectric Cells.* **E. Barkow.** (Phys. Zeits. 18. pp. 214–225, May 15, 1917.)—Results are given of various modifications of photoelectric cells, chiefly potassium cells with hydrogen or argon. [See Abs. 128, 1871 (1914)]. C. P. B.

1176. *The Electrical Properties of Gases.* **J. J. Thomson.** (Engineering, 103. pp. 455–456, May 11; 478–479, May 18; 503–505, May 25; 527–528, June 1; 549–550, June 8; and pp. 573–575, June 15, 1917. Lectures delivered before the Roy. Inst. Electrician, 79. pp. 314–315, May 25, and pp. 505–507, June 29, 1917.)—For the description of the numerous experiments which were carried out during the lectures the original pages must be referred to. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

1177. *Residual Magnetism and Magnetic Shielding.* **E. Wilson** and **J. W. Nicholson.** (Roy. Soc., Proc. 93. pp. 398–412, Aug. 1, 1917.)—Continuing a research on the magnetic shielding of large spaces [see Abs. 1289 (1916), and 549 (1917)], the present paper deals with the influence of residual magnetism in the four shells of the shield. It is found that the ordinary process of demagnetisation by reversals fails to be completely effective if a constant magnetic field, such as that of the earth, is present at the same time. Complete removal of previous magnetic history of the shells has been found possible, provided that during the preliminary demagnetisation of the shells the earth's field on them is annulled. The magnetic shield described in the earlier papers has now the degree of shielding required by theory; it is capable of reducing the earth's field to an order as low as 0·001 c.g.s., and its properties do not change appreciably with lapse of time. The well-known fact that iron polarised by a large force, and subsequently tested for permeability at a lower force, shows diminished permeability at the lower force gives, in combination with these results, an interpretation of the increase of permeability manifested by iron when tested within a magnetic shield.

G. E. A.

1178. *The Structure of Magnet Steel and its Change with Heat Treatment.* **K. Honda** and **T. Murakami.** (Tôhoku Univ., Sci. Reports, 6. pp. 58–70, July, 1917.)—A magnetic, thermal, and microscopic investigation of the following specimens of magnet steel :—

Percentage of	C	P	S	Mn	Si	W
Böhler	0·47	0·016	0·016	0·20	0·24	5·38
Sweden	0·59	0·015	trace	0·20	0·23	4·82
Yonago	0·61	—	—	—	0·27	4·98
Nagoya	0·36	—	—	—	0·20	6·00

The results of the investigation are shown in the paper by (*a*) a series of magnetisation-temperature curves taken for a normal and an extremely slow rate of heating—

Normal Rate :

Heating ...... 20° ←—35m—→ 650° ←—10m—→ 900° ←—10m—→ 1000°
Cooling ...... 20° ←—50m—→ 550° ←—10m—→ 900° ←—10m—→ 1000°

Slow Rate :

Heating ...... 20° ←—85m—→ 650° ←—2h to 4h—→ 900° ←—6m—→ 1000°
Cooling ...... 20° ←—50m—→ 650° ←—2h to 3h—→ 900° ←—6m—→ 1000°

(*b*) heating and cooling curves taken by means of a transformation-point indicator constructed by Leeds and Northrup; (*c*) 12 microphotographs showing the structure under various conditions. The three methods of analysis agree with one another, and lead the authors to the following conclusions:—(1) In magnet steels the presence of two carbides, Fe_3C and WC, is probable. (2) These two carbides can exist either as a double carbide or separately according to the heat-treatment. (3) If the specimen be once heated to 800°–900° C. and then slowly cooled, the two carbides exist as a double carbide. (4) Above Ac_1 point the double carbide decomposes into its components, both dissolving in austenite, and remaining as such up to about 900° C. (5) On further heating, WC dissociates into W and C, both remaining dissolved in austenite. This dissolved carbon forms with iron the iron cementite in solid solution. The degree of dissociation increases with rise of temperature, and becomes almost complete at about 1100° C. (6) By cooling the specimen from a temperature higher than 1100° C. with the normal rate, the A1, A2, A3 transformations are brought down to a much lower temperature than A1 point by the retarding effect of W dissolved in austenite. (7) At about 550° the retarded A3 transformation begins to take place, and with it the ferrite-dissolving tungsten separates from the solid solution, continuing to do so for some 50 deg. till the concentration of the solution reaches such a value that the eutectic A1 transformation becomes possible. Then this transformation takes place somewhat abruptly at about 500° C., and iron cementite is set free. (8) It is very difficult to make the two carbides combine during the process of slow cooling if the max. temperature exceeds 1100° C. (9) If, however, the specimen be cooled to room temperature and reheated to 800°–900° C. this recombination of the two carbides takes place on cooling. (10) If the specimen, previously heated to 1100° C., be kept constant at about 700° for a sufficiently long time, the dissolved W gradually takes C in iron cementite to form tungsten cementite, and A1 transformation takes place at this temperature, showing that the effect of W is to retard the transformation. L. L.

1179. *Large Electromagnet of Simple Construction.* **T. Svedberg.** (Ann. d. Physik, 52. 6. pp. 657–664, July 17, 1917.)—Description of an electromagnet of simpler construction than those of Weiss and Du Bois, on whose data the author's calculations are founded [see Abs. 1090 (1907), and 2115 (1909)]. The shape of the magnet is a rectangular frame of iron on an iron base, the poles projecting inwards from the middle of the opposite sides of the frame. Transport is facilitated by having the iron of the magnetic circuit in six separable parts. The dimensions of the frame are 77 cm. extreme length, 55 cm. extreme height, sectional area of frame 15 × 7·5 cm. The weight of the magnetic circuit is 262 kg., that of the base 102 kg., and that of the pole-pieces 9–12 kg. per pair. The pole windings were made to suit an applied voltage of 420–480, and were of copper wire 2 mm. thick, and contained about 4500 turns with about 20 ohms' resistance, calculated to carry about 20 amps. and to give about 185 kiloamp.-turns in the maximum. Each coil consists of six coaxial cylindrical coils contained one within another and separated from each other by a water-jacket. From a table of results the highest field of 21·5 kilogauss was obtained with a current of 20·5 amps., the dimensions of the air-gap being: length 2 cm., diameter 8 cm. An illustration of the electromagnet is given, the makers being Messrs. Rose, of Upsala. G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1180. *An X-ray Tube for Physical Research.* **H. v. Traubenberg.** (Phys. Zeits. 18. pp. 241–242, June 1, 1917.)—For scientific research the ordinary X-ray tubes, as used for medical purposes, are unsuitable on account of their relatively short life and consequent costliness. Hence the author has designed and constructed a robust form of X-ray tube which is relatively inexpensive. Using this tube, it is possible to obtain an intense beam of X-rays of variable penetrating power. A suitable fitting is introduced which renders it easily possible to take out and replace the antikathode with different substances, so that the tube can be used as a source of characteristic X-rays of any required substance.

Such tubes were used by Debye and Scherrer [Abs. 1130 (1916)] in their researches on interference of X-rays. A. B. W.

1181. *Arrangement for the Production of Continuous High-tension Currents for use with Röntgen-ray Tubes.* **O. M. Corbino** and **G. C. Trabacchi.** (Archives d'Él. Médicale, 25. pp. 249–262, June, and pp. 345–357, Aug., 1917.)—A French version of the paper dealt with in Abs. 836 (1917).

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1182. *The Curves of the Periodic Law.* **W. M. Thornton.** (Phil. Mag. 34. pp. 70–75, July, 1917.)—The paper deals with the curves from the standpoint of the disintegration theory of matter. On the latter hypothesis atomic structure is modified by the loss of electrons in a regular sequence, from positions of max. atomic volume to those of max. density. The periodic curves of density and atomic volume both have the inflection characteristic of hysteresis. They can be built up on the assumption that the internal force by which atoms are held together passes through a simple periodic change, and that in the resultant change of atomic volume there is structural hysteresis. If all aggregates of electrons forming atoms had the same mean density of concentration, atomic volumes would increase indefinitely in a straight line; the density oscillates, however, between two limits, and curves are given showing the true relationship between atomic volume and atomic weight, together with the various density lines. Superposed upon the lines of mean density of volume there is an oscillation, which, since the change from maximum to minimum takes place in a regular periodic manner, and so that the rate of change is never discontinuous, may be assumed to be caused by a simple periodic variation of cohesive force. Using the conception that there is structural hysteresis in taking up new atomic formations, the author proceeds to interpret the various curves. The change of atomic volume with atomic weight, generally taken to illustrate the periodic law, is shown to be built up from two components: (1) An asymptotic rise of mean volume to a maximum which coincides with the radio-active elements. (2) A periodic oscillation, giving a displacement modified by structural hysteresis, increasing in amplitude and period, there being six known minima which in the absence of abnormal forces correspond approximately with the cubes of the first six natural numbers. It is shown that the atomic formation oscillates between two limiting conditions, that in which the density is constant and a minimum, and that in which the volume is constant and a minimum. There is a gradual adjustment between the conditions of minimum density and minimum volume. In the former the ratio of the mass to the volume of the atom is constant, so that the closeness of packing of the positive electrons within the atom is constant. In the latter the ratio of mass to density is constant; the system has constant volume and is therefore elastic in the sense that at the higher densities more electrons are packed into the same space. As the internal cohesion is relieved by the successive loss of units carrying positive electrons the atomic weight falls, the volume expands to a maximum, declining again to a minimum under the elastic forces of the remaining matter, and any theory of atomic formation must be capable of explaining the change of volume in so great a ratio as 18·75 to 1. In the curve of atomic volumes between cæsium and osmium there is evidence of a sub-oscillation reaching a maximum at an atomic weight of about 180. Such an oscillation superposed on a regular periodic curve has the effect of displacing the maximum of the wave on which it falls, and the atomic volumes with cæsium as a maximum are clearly spaced unsymmetrically in consequence. As disintegration proceeds and atomic weight falls the steady component of cohesion begins to rise in importance in those elements having an atomic weight below 180. The atoms are then changing from a condition of constant volume, but the steady force coming into play is sufficient to delay the change to the opposite condition of constant minimum density, *i.e.* a return to the minimum of volume from which the oscillation of force proceeds regularly. It is remarkable that this region of variation is that of the rare earths, and it is now suggested that the reason for their comparative fewness is that the forces under which atoms are formed are modified by the rise in importance of the steady central force, so that there is here, in a sense, instability of type of structural formation, and permanent elements are rare. On the degradation theory of atomic formation some form of retarding action is necessary, otherwise matter would slip without resistance to its lowest elements. In the consecutive loss of nuclear units from the outer ring the forces controlling the size of an atom rise and fall in a regular manner, and because of this periodic change retardation takes the form of cyclic hysteresis. An atom about to lose a unit of mass must be supersaturated, which is a lag of state behind controlling force. H. H. Ho.

1183. *Nature of Chemical Affinity in the Combustion of Organic Compounds.* **W. M. Thornton.** (Phil. Mag. 34. pp. 66–70, July, 1917.)—The final stage in the combustion of organic compounds is combination in a gaseous state. Affinity is then probably of the simplest kind, for molecules are far apart, and they are in contact for the briefest possible time. In the absence of any knowledge of how an electron, acting as a bond, is anchored into the atomic structures of combining atoms, the force that a bond sustains is assumed by the author to obey, as a first approximation, the usual laws of attraction, and to be proportional to the products of the nuclear charges, *i.e.* of the masses of the molecules. It is clear, however, that affinity is not a simple electrostatic attraction, and that between elements it is dependent upon atomic formation.

The most recent comparisons of affinity in gases are those by Bone, made by exploding mixtures at high initial pressures. In the case of the mixture $CH_4 + O_2 + 2H_2$, the affinity for oxygen of the methane and hydrogen is found experimentally to agree with the calculated values when the respective affinities are taken as proportional to the product of their combining masses.

The author investigates an old conception of the source of heat in combustion, viz., that in an explosive mixture before ignition the molecules collide without liberation of heat, but when activated in the wave-front they combine with increased kinetic energy of which the heat set free is a measure. He opines that this view has the merit of giving a clear picture of the initiation of the process, and proceeds to extend it by consideration of the velocities of combination. It is shown that an affinity similar to the gravitational law holds over a wide range of those compounds which are reduced to similar products of both steam and CO_2. Hydrogen and CO are not reduced to the same products, and their affinities are not comparable in terms of heat of combustion. For this reason it is impossible to compare the affinities of elements thermally, and heats of oxidation of metals differ widely. Bone's results show that the affinity of hydrogen for oxygen follows the same mass-law as organic compounds, and that heat of combustion is only under strict limits a reliable means of comparison. That chemical affinity in its simplest form is proportional to the product of combining masses does not necessarily identify cohesion and gravitation, though it makes such a relation possible. The difficulty in establishing it in liquids or solids would be to find an expression for, or an experimental means of observing the action of surrounding mass. By analogy with its known influence in electro-optical phenomena [see Abs. 868 (1911)] it might be expected that this effect would be to dilute affinity without changing the ultimate law, but the coefficient of dilution would certainly not be constant. H. H. Ho.

1184. *Determination of the Iron-Carbide Diagrams by Etching* in vacuo. **N. Tschischewsky** and **N. Schulgin.** (Iron and Steel Inst., J. 95. pp. 189–198; Corres., 199–201, 1917. Engineering, 103. pp. 485–487, May 18, 1917.)—K. Krooglak (Russ. Metall. Soc., J., 1915) having shown that the preheating of sections in a gaseous atmosphere (N and H) prior to etching decarburises the iron, the authors heat and etch by means of chlorine gas in the vacuum of an Heræus furnace for the special purpose of determining the cementite line SE at high temperatures. The specimens used were a cement steel from the Ural (0·89 % C) and a series of mild steels prepared in a Tammann furnace from Swedish rail iron (0·1 % C) and Swedish cast-iron (3·96 % C), the resulting alloys containing 2·5, 1·505, 1·25 % C. The specimens were cut into discs, filed round and polished, the exposed area being 0·5 cm.^{2}. The specimen was placed in the projecting end of the horizontal furnace tube, the tube then evacuated (vacuum measured by aid of Crookes tube) and inclined at 30 or 40°, so that the specimens rolled down to the thermo-couple in the tube, which was then levelled again and slowly heated; chlorine was afterwards admitted. The etched surface looked dull, dark when much chlorine was used, and had to be varnished to prevent oxidation. The tests, as well as preliminary tests with other steels, were made at temperatures ranging from 635° up to 1015° C.; the specimens were also etched with sodium picrate or picric acid, sometimes after filing off the surface layer of the chlorine-etching to a depth of 1 mm. The authors consider that the heating of the sample above the pearlite line would cause the cementite to dissolve and disappear at a temperature corresponding to the SE line; when the heating and etching by chlorine did no longer indicate the presence of cementite, it was assumed that the SE line had either been reached or crossed. A distinct polyhedric structure mostly indicates overheating above SE. Assuming that E marks the saturation limit of iron (1·7 % C) with cementite at 1130° C. and S the eutectic point of 0·9 % C iron at 700° C., the resulting SE line was found to be straight and to pass near or between the points determined by Wark and by Saldau and Goerens.
H. B.

1185. *Case-hardening of Iron by Boron.* **N. Tschischewsky.** (Iron and Steel Inst., J. 95. pp. 185–187, 1917. Engineering, 103. p. 472, May 18, 1917.)—The author and A. Herdt [Russ. Metall. Soc., J., No. 4, 1915] having found that iron-boron alloys on cooling retain some boron in the form of a hard solution, the author tried case-hardening by boron. Two experiments are described. In each a cube of soft iron (0·12 % C) was drilled to half its length, and the cavity filled with amorphous boron or with ferro-boron (19 % B) and plugged with the same iron under hydraulic pressure. The specimens were then heated in an Heræus furnace for two hours to 950° C. The boron penetrated into the iron to a depth of 1 mm., forming a hard white layer of compact boric pearlite with a twin crystal structure. At lower temperature a less hard and brittle alloy was obtained; ferro-boron is preferable to amorphous boron. H. B.

1186. *Steel Ingot Defects.* **J. N. Kilby.** (Iron and Steel Inst., J. 95. pp. 69–89; Disc., 90–106, 1917. Engineering, 103. pp. 437–439, May 4, 1917.)—A good percentage of the defects in steel ingots come under the following heads which are dealt with in this paper:—Pipe; Segregation; Occluded slag; Fluxed fireclay; Lappiness; Cracks. Illustrations are given showing the position of pipes in ingots and the effect of these on forged bars. The effect of composition of slag in open-hearth furnaces is discussed and illustrated by means of diagrams. Lappiness in ingots and its effect on forged and rolled bars is dealt with and records are given showing effect of teeming speeds in top- and bottom-cast ingots on the number of cracked ingots obtained. C. O. B.

1187. *Exfoliation and Carbon Concentration in the Case-hardening of Steel.* **E. P. Stenger.** (Met. and Chem. Eng. 16. pp. 424–433, April 15, 1917.)—It frequently happens that the cemented zone of a case-hardened object subject to shocks splits away from the core. Exfoliation is evidently caused by internal strains possibly set up by the different expansions of the high-carbon case and the low-carbon core during hardening. Cementation experiments have been carried out on ordinary case-hardening steel, an electric-furnace-refined mild steel, a case-hardening nickel steel and a chrome steel containing 0·58 % C, 1·4 % Cr, and 0·75 % Ni. Giolitti's hypothesis that cementite segregations are the outcome of oscillations of temperature is confirmed. Cementite segregations give rise to local flakings which should not be confused with exfoliation, in which the whole case splits off. After grinding off the cementite segregations the carbon contents of the specimens were determined by analysis and plotted as functions of the temperatures of the cementation. The curves obtained do not quite coincide with the line SE of the iron-carbon diagram, which confirms the gaseous theory of cementation. Determinations of the density of quenched specimens indicate that in plain steels and chrome steels the specific gravity decreases with increasing carbon-content. In the case of Ni steel the density is increased by quenching. A mathematical analysis of the stresses set up by the difference of volume-changes of core and case proves that this is the prime cause of exfoliation. F. C. A. H. L.

1188. *Manganese Steels.* **A. Portevin.** (Comptes Rendus, 165. pp. 62–65, July 9, 1917.)—The author has previously shown [Abs. 1405 (1911)] that by sufficiently slow cooling, pearlite could be developed in chrome steels which up to that time had only been known in the martensitic state. Similar experiments made on a 7 % Mn steel with 0·5 % C show that after heating to 1000° C. for 75 hours followed by slow cooling, the microstructure consists of martensite and rounded grains of lamellar pearlite; the lamellæ having a tendency to arrange themselves radially or in fan-tail fashion. Slowly cooling a 12 % Mn steel containing 1 % C results in the co-existence of lamellar pearlite and austenite, often separated by a thin layer of troostite. Complexes of troosto-pearlite, martensite, and austenite are also obtained, in which case the martensite needles cross the austenite grains in three directions. F. C. A. H. L.

1189. *Anomaly of Cementite in Carbon Steels, Annealed, Hardened and Semi-hardened.* **P. Chevenard.** (Comptes Rendus, 164. pp. 1005–1008, June 25, 1917.)—The magnetic transformation of cementite, discovered by Wologdine [Abs. 902 (1909)], is accompanied by a discontinuity in the dilatation curve. Differential dilatability curves of nine pure carbon steels have been taken against a sample of carbonless electrolytic iron. All the curves show a reversible negative dilatation similar to that observed in ferro-nickels of the group Fe_2Ni. The peak of the transformation occurs at 210° C., coinciding with the temperature of loss of magnetisation of cementite. Above 300° C. the curves are quasi-rectilinear; the amplitude of the anomaly is approximately proportional to the carbon-content and at 15° is equal to $8{\cdot}8 \times 10^{-4} \times C$, where C is the percentage of carbon. The study of the anomaly can be used as a method of determining the state of the carbon in a heat-treated steel. The dilatation curve of a hardened steel shows no trace of the cementite change after heating to 250° C. Above this temperature the cementite change gradually increases in magnitude and attains its normal value after heating to 700° C. This confirms the identity of the annealed with the max. tempered condition and the similarity of sorbite and pearlite in constitution. In the case of incomplete quenching the dilatometer reveals the anomaly after the first heating to 250°; the amplitude of the phenomenon decreases as the proportion of martensite increases. Troostite is regarded as a complex of the two phases: ferrite and cementite. F. C. A. H. L.

1190. *Influence of High Temperature upon the Elastic and Tensile Properties of Wrought Iron.* **F. A. Epps** and **E. O. Jones.** (Met. and Chem. Eng. 17. pp. 67–71, July 15, 1917.)—Describes the method of carrying out the experimental work and gives curves showing a summary of the results obtained. The ultimate strength appears to increase as the temperature increases from 70° F. until a maximum is reached between 350° and 550° F. From the temperature of max. strength the tenacity diminishes rapidly until 1000° F. is reached. The greatest gain over the strength of the metal at 70° F. was 37·6 % which occurred at 480° F. The loss at 1000° F. over the strength of the metal at 70° was 58·5 %. The elastic limit appears to decrease from 70° F. to about 270° F. showing a max. decrease of 13 %. From 270° F. the elastic limit appears to increase suddenly up to 350° F. where it reaches its max. value of about 10 % above the stress at 70° F. Above 350° F. it gradually drops, and at 1000° F. shows a loss of 70 % over the elastic limit at 70° F.

Owing to a period of rapid yielding without increase of stress, the yield-point is well defined at moderate temperatures. The yield-point, however, vanishes at about 500° F.

With regard to elongation, at 300° F. and 900° F. the metal shows only about half the elongation shown at 70° F. The contraction of area varies with the temperature of the bar, being much less at 200° F. and 600° F. than at 70° F. C. O. B.

1191. *Influence of Rate of Cooling on Transformation-temperature of Steel.* **A. Portevin** and **Garvin.** (Comptes Rendus, 164. pp. 885–888, June 4, 1917.)—It has been known since Osmond that the temperature of the transformation of steel is lowered when the steel is rapidly cooled, but the temperature corresponding to a certain rate of cooling was unknown. The problem might be investigated either by modifying the rate of quenching for identical specimens or by quenching similar specimens of different masses under the same conditions. The latter method is preferable although the cooling of the surface and of the interior of the specimen does not take place at the same rate. The experiments were made [as in Abs. 1914 (1914)] on cylinders of diams. ranging from 8 mm. up to 20 mm. and three times that height. It results that the lowering of the transformation temperature is not progressive with more rapid cooling; but the temperature is abruptly lowered, and the transformation becomes slow and less distinct at low temperatures, so that comparison wires of 30 % nickel steel have to be used. When the transformation takes place at high temperature, troostite is obtained: when at low temperature, martensite. The troostite consists of the same constituents as the pearlite; the hardness changes with the division of the cementite and ferrite phases. The existence of martensite is correlative to a transformation which begins at low temperature and proceeds at a slow rate, remaining incomplete. Brush and Hadfield [see Abs. 564 (1917)] observe a spontaneous generation of heat in recently hardened steel. When troostite and martensite exist simultaneously, the curve shows an anomaly at high temperature and again at low temperature, so that the transformation appears to be split (*dédoublée*). There is a critical value in the rate of cooling for the change in the transformation temperature, and this critical value depends upon the composition of the steel, but is not always in the same sense as the carbon percentage; there seems to be a minimum for the eutectic composition. These phenomena are more easily observable in nickel-chromium and chromium-tungsten steels, where they occur with less rapid cooling. The hardening of steel thus seems analogous in a certain sense to superfusion and supersaturation. H. B.

1192. *Mechanism of the Quenching of Carbon Steels.* **P. Chevenard.** (Comptes Rendus, 165. pp. 59–62, July 9, 1917.)—Based on the observation that the rate of cooling of a red-hot steel wire in an inert atmosphere varies between wide limits, combined with the use of his autographic differential dilatometer, the author has devised a new method of studying the mechanism of quenching. In hydrogen the steel is hardened and in nitrogen annealed, while intermediate states can be obtained by the use of a mixture of the two gases. The transformation (at first simple) on cooling depends on the temperature attained in heating; as this increases *Ar* is progressively lowered until, on passing a certain temperature θ_0, the transformation splits up and one part is retarded and occurs at a low temperature (200°–300° C.). The retarded part of the change gradually increases at the expense of the portion which subsists at the high temperature until, above a temperature θ_1, the retardation is complete. θ_0 and θ_1 approach each other as the rate of cooling increases, and for very rapid rates they occur at the end of *Ac*. The simple transformation corresponds with the annealed state (pearlite and minimum hardness), while the completely retarded transformation gives the hardened state (martensite and max. hardness). Splitting of the transformation gives the intermediate states, microscopic examination of which reveals the presence of both troostite and martensite. These results confirm the conclusions of Portevin and Garvin [see preceding Abs.] F. C. A. H. L.

1193. *Grain-growth in Deformed and Annealed Low-carbon Steels.* **R. H. Sherry.** (Faraday Soc., Trans. 12. pp. 284–299; Disc., 299–304, June, 1917. Chem. News, 115. pp. 3–6, Jan. 5, and pp. 15–18; Disc., 18, Jan. 12, 1917.)—Gives the results of an investigation of the occurrence of coarse crystallisation in low-carbon steel in various commercial forms.

During this investigation the materials examined were hot-rolled rod, cold-drawn wire, hot- and cold-rolled sheet, cold-rolled strip, and cold-drawn tubing and pressings. The effects of forging hot and cold were investigated on a small scale, and the quantitative effect of permanent deformation received special attention. The following are the conclusions arrived at:—

(1) Grain-growth in low-carbon steel will be produced by permanent deformation of the metal within certain limits, followed by annealing within certain temperature ranges. (2) The greater the amount of strain within these deformation limits, the smaller will be the grain-size produced by annealing. (3) The limits of the annealing range within which grain-growth due to permanent deformation will be produced are 650° and 900° C.

(4). When the strain is less than a certain or "critical" amount, the annealing range within which grain-growth can occur seems to be limited by the thermal critical points at about 690° and 780° C. (5) The most practical standard by which to measure permanent deformation seems to be the reduction of area. Experiments show that no grain-growth occurs following a reduction of area of less than about 7 % or more than 25 to 30 %. The critical strain seems to be about 9 %. (6) The refining action takes place at 780° C. (7) The presence of carbon causes a suppression of grain-growth. No grain-growth was found to occur in steels which were uniformly above 0·18 % in carbon-content. C. O. B.

1194. *Do Equiatomic Solutions in Iron Possess Equal Resistances?* **E. D. Campbell.** (Faraday Soc., Trans. 12. pp. 274–281; Disc., 281–288, June, 1917. Chem. News, 115. pp. 45–48, Jan. 26, 1917.)—Contains the results of experimental work to determine the relation existing between the carbon concentration and specific resistance of heat-treated steels. The specific resistances of 7 steels varying from 0·04 to 1·05 % carbon in the hardened and annealed condition are given and are compared with the figures calculated from Benedicks' formula. A second table shows the specific resistances at 25° and 95° C. of the steels quenched from 907° C. and tempered at 105° C., and also after annealing from 880° C. C. O. B.

1195. *Grain-size Measurements in Metals.* **Z. Jeffries.** (Faraday Soc., Trans. 12. pp. 40–53; Disc., 54–56, June, 1917. Chem. News, 115. pp. 193–194, April 27; 205–207, May 4, and pp. 218–219, May 11, 1917.)—Fine grain and high tensile strength and elastic limit and hardness generally go together; Fahrenwald prepared pure gold of four degrees of hardness, from 94·7 to 23·8 Brinell numbers, by starting from colloidal gold. Grain-size measurements are made on polished, etched specimens which require no further preparation. The grains are counted in various ways (Heyn, Grard). The author counts the grains within a circle, generally of 79·8 mm. diam., well within the microscopic field; when the circle encloses 66 grains and cuts 28, the average number is $66 + 28 \times 0{\cdot}6 = 82{\cdot}8$ grains; the factor 0·6 is the mean of many determinations made, the values of which ranged from 0·54 to 0·62. In the *discussion*, **R. Hadfield** mentioned that a 0·58 % C steel contained 5540 grains per sq. in. as forged, 4100 after annealing, and 330,000 when water-gas quenched and reheated. **F. C. Thompson** commented on the correlation between grain-size and physical properties. H. B.

1196. *Changes in Properties of Aluminium with Mechanical Work.* II. *Specific Heats of Hard and Soft Aluminium.* **F. J. Brislee.** (Faraday Soc., Trans. 12. pp. 57–62; Disc., 62–63, June, 1917.)—The results are given of the experimental determination of the specific heat of Al in the worked and annealed condition. The metal was drawn into square bars with 1-in. sides, into ⅜-in. rod and into wire 0·084 in. diam. The following results are given:—Specific heat of annealed Al in range 300° to 20° C.: mean of 28 determinations 0·2854; range 200° to 20° C., mean of 12 determinations 0·2240. Specific heat of wire, range 100° to 20° C., mean of 7 determinations 0·2220; after heating wire at 100° C. for 10 days, mean of 4 determinations 0·2175. [See also Abs. 1769 (1918).] C. O. B.

1197. *Note on the Annealing of Aluminium.* **R. Seligman** and **P. Williams.** (Faraday Soc., Trans. 12. pp. 64–65; Disc., 65, June, 1917.)—By heating hard worked Al to 125° C. a definite change in the rate of solution in nitric acid is brought about. A sample of hard worked Al which lost 56 mgm. per 100 cm.^{2} per 24 hours when immersed in nitric acid of density 1·42, only lost 39 mgm. when similarly exposed after being annealed at 500° C. On prolonging the heating the decrease in the rate of dissolution is not augmented, for as the heating to 125° is prolonged the fall in the rate of dissolution diminishes until samples heated for 80 hours show the same or a slightly higher rate of dissolution than samples which have not been heated at all.

It is also found that Al which has been freshly annealed has a lower rate of dissolution in nitric acid than a sample of the same metal which has been allowed to stand for several days after annealing. [See also Abs. 1587 (1915) and 1093 (1916).] C. O. B.

1198. *Properties of Solid Solutions of Metals and of Intermetallic Compounds.* **F. C. Thompson.** (Faraday Soc., Trans. 12. pp. 23–29, June, 1917.)—A theoretical paper, in which evidence is adduced that the remarkable hardness and high electrical resistivity of solid solutions point strongly to the fact that they are caused by crystalline distortion similar to that which arises from the cold-working of metals. This is explained on the theory that the process of crystallisation of such solutions causes an equalisation of the atomic volumes of the constituents. Elastic stresses are thus set up, which, in their turn, by increasing the resistance to further stresses, raise the hardness of the mass. Such a theory leads to a parabolic relation between the hardness and the concentration, with a maximum at a composition of 50 atoms per cent. of each metal. The gold-silver alloys give such a parabolic curve, which corresponds exactly with the theoretical curve. The same theory may also be used to explain the hardness and fragility of the intermetallic compounds. T. S. P.

1199. *Molecular Attraction.* XIV. *Specific Heats of the Elements and some Energy Changes.* **J. E. Mills.** (J. Phys. Chem. 21. pp. 345–381, May, 1917.)—The author has here collected what he regards as the most trustworthy data referring to the specific heats, heats of fusion, heats of vaporisation, and heats of transformation from one allotropic form into another, of the elements. These data are to be discussed in a subsequent communication. T. H. P.

1200. *The Relation of Osmotic Pressure to Temperature.* **W. F. Magie.** (Phys. Rev. 10. pp. 64–72, July, 1917.)—An extension of a former paper [Abs. 581 (1913)] in which the author deduces a formula for the relation of the osmotic pressure to the temperature, from a study of the boiling- and freezing-point cycles. A. F.

1201. *Osmotic Pressure and its Relation to the Membrane Solvent and Solute.* **F. Tinker.** (Phil. Mag. 33. pp. 428–450, May, 1917.)—Referring to his previous papers [see Abs. 330, 334, 1257 (1916)] the author points out that, with the exception that moisture travels across a semi-permeable membrane in a much more condensed condition than vapour proper, the phenomenon of osmotic flow is very similar to that of vapour flow. Diffusion proceeds from the pure solvent to the solution because the pure solvent induces a greater pressure and concentration inside the membrane than the solution does. In the present paper the osmotic pressure is quantitatively connected with the conditions inside the pure solvent, the solution and the membrane. The considerations are based upon Dieterici's equation of state, it is stated, and the results are of value only in so far as this equation accurately represents the conditions inside fluids. The author considers processes operative during solution; partial pressures of solvent and solution inside the solution and of solvent and solute in the vapour phase; ideal and non-ideal solution; phenomena of osmotic flow; and conditions of equilibrium. His final equation expresses the osmotic pressure in terms of concentrations, volume changes on solution, and the 8 coefficients of compressibility for this pure solvent, pure solute, and solution. This equation resembles that of van Laar for an ideal solution, except that it includes the heat of solution. It is confirmed by a consideration of the fundamental relation ship deduced between the coefficients of compressibility of a liquid and of its free space; the compressibility data (ether, ethyl chloride and acetate; benzene, pentane, octane, etc.) are taken from Landolt and Börnstein's tables. H. B.

1202. *Semi-permeable Membranes and Negative Adsorption.* **W. D. Bancroft.** (J. Phys. Chem. 21. pp. 441–458, June, 1917.)—The author reviews the work, more especially of Bigelow and of Bartell and Hocker [Abs. 831 (1916)] on osmotic action of porous septa, as well as the work of others dealing with semi-permeable membranes. He arrives at the following conclusions:—(1) We may have osmotic phenomena with a porous diaphragm, provided we have very marked negative adsorption, and provided the diam. of the pores is so small that the adsorbed films fill practically the whole of the pores. (2) A porous diaphragm will act as a semi-permeable membrane in case there is no measurable adsorption of the solute, and in case the adsorbed films fill the pores completely. (3) In the usual case of a semi-permeable diaphragm, we do not have a porous diaphragm, and the semi-permeability is due to the fact that the solvent dissolves in the diaphragm while the solute does not to any appreciable extent under the conditions of the experiment. (4) A liquid is not to be considered as a porous substance and solubility does not depend on porosity. A. F.

1203. *Studies of Solution.* I. *The Change of Molecular Solution Volumes in Solutions.* **S. Horiba.** (Kyōtō Coll. Sci., Mem. 2. pp. 1–43, March, 1917.)—In a work of much importance the author has studied the molecular solution volumes of solvent and of solute in aqueous solutions of cane sugar and of the alkali halides. The method employed was as follows: If m_s moles of solute be present in one litre of solution of specific gravity s, the moles of solvent m_ω in the solution is $m_\omega = (1000s - m_s\mathrm{A}_s)/\mathrm{A}_\omega$, where A_s and A_ω are the molecular weights of solute and solvent respectively. If ϕ_s and ϕ_ω be the molecular solution volumes of solute and solvent respectively, we have the relation, $m_s\phi_s + m_\omega\phi_\omega = 1000$. The molecular solution volumes are functions of the concentration, but when the change of concentration is not large, we get the two equations $m_{s1}\phi_s + m_{\omega 1}\phi_\omega = 1000$, and $m_{s2}\phi_s + m_{\omega 2}\phi_\omega = 1000$. From these equations we can calculate two unknown quantities ϕ_s and ϕ_ω. That is, if two solutions are taken which have known concentrations, we can calculate the molecular solution volumes of solute and solvent in the solution which has the mean concentration of the two solutions chosen. To know the concentrations of the solution, we must determine the specific gravity of the solution which has the known weight percentage of solute. If the molecular weights of solvent and solute are both unknown, we can calculate the relative volume-change in the same way, and the method of calculation is therefore applicable to the case where the solute or solvent have ionised or polymerised in the solution. By this method the author has determined the molecular solution volumes of cane sugar, potassium chloride, sodium chloride, ammonium chloride, and lithium chloride in aqueous solution at several temperatures. It is found that the molecular solution volume of the solute increases with the increase of its concentration, while the molecular solution volume of the solvent decreases as the concentration increases. If the compression of the molecular solution volume of the solvent be represented in terms of pressure, it is found that the pressure values so obtained are less than the values of the inner pressure obtained by Tammann, but are greater than the osmotic pressure values in the case of cane-sugar solutions. In dilute solutions the author's values are nearly equal to the values of the osmotic pressure. The author also shows that when the molecular solution volume of the solute reaches a certain value, the solution becomes saturated, and this molecular solution volume in the saturated solution is almost equal to the molecular volume of the solute in the pure state.

II. *A Conception of Osmotic Pressure.* (Ibid. pp. 45–57, March, 1917.)—From the results obtained in the first part of the author's investigation, the conclusion is reached that the osmotic pressure can be explained as the solutional pressure of the water into solution, and the inner pressure of compression of the solvent in solution is the first cause of the osmotic pressure. The analogy of the gaseous state and solution is considered by the author to be questionable. A. F.

1204. *A Contribution to the Theory of Solution.* **E. J. Hartung.** (Faraday Soc., Trans. 12. pp. 66–84; Disc., 84–85, June, 1917.)—Some years ago [Abs. 318 (1913)], Denison expressed the view that the divergences of solutions from the mixture law are to be explained mainly by solvate formation, that more than one solvate is not likely to be present, and that the composition of the solvate may be inferred from a quantitative study of such divergences. The author has now undertaken a series of measurements of the density, heat capacity, and heat change on mixing, of mixtures of selected pairs of liquids. From these measurements he concludes that, in the cases examined, no simple solvate theory will suffice to explain the experimental results, even though the liquids used, with one exception, are little associated. Also, a study of the deviation curves obtained from many other liquid-pairs by various authors leads to the conclusion that only in rare cases if at all, will the conditions be simple enough to permit of an explanation of the deviations by single solvate formation. In the great majority of cases the molecular condition of a mixture of two liquids is much more complex, and it becomes very difficult to develop and apply any satisfactory quantitative theory. In the *discussion,* **A. W. Porter** considered that the Denison equation was fundamentally unsound. He had found that all the data obtained by him could be represented by the single equation $x = a(m - c_1x)(1 - m - c_2x)$, an equation which is precisely what would be expected if the deviation is due to the gradual change in the effective Laplace pressure as the proportion of the two substances present is varied. A. F.

1205. *Current Potentials of Electrolytic Solutions.* **H. R. Kruyt.** (K. Akad. Amsterdam, Proc. 19. pp. 1021–1028, 1917.)—In extension of his previous work [see Abs. 228 (1915)], the author has now investigated the current (contact) potentials of solutions of hydrochloric acid and of *p*-chloraniline hydrochloride. These solutions, as did also those of the chlorides of potassium and barium, give a max. contact potential between the concentrations of 0 and 1000 millimols. per litre. This result is discussed in connection with the chemistry of colloids, the stability of suspensoids, and the iso-electric points. T. S. P.

1206. *Applicability of the Isohydric Principle to Tenth-normal Mixtures of Hydrochloric Acid and Potassium Chloride.* **N. E. Loomis, J. L. Essex, and M. R. Meacham.** (Am. Chem. Soc., J. 39. pp. 1133–1139, June, 1917.)—The authors have carried out electromotive measurements with the system $H_2 - Pt/0{\cdot}1N(HCl + KCl) - Hg_2Cl_2/Hg$, for mixtures ranging from 0·09 N-HCl + 0·01 N-KCl to 0·01 N-HCl + 0·09 N-KCl. In every case it was found that the e.m.f. of the system is higher than the value calculated frm the isohydric principle. This result has led to the conclusion that the isohydric principle does not apply rigidly, but that there is a slight increase in the dissociation of the hydrochloric acid with increasing proportions of potassium chloride. In the most extreme case, the mixture of 0·01 N-HCl + 0·09 N-KCl, the dissociation of the acid appears to have increased from 86 to 86·68 %. The reason for this increase is not definitely indicated by this work. [See also Abs. 177 (1917).] A. F.

1207. *Electrolytic Estimation of Zinc.* **F. Chancel.** (Soc. Chim. France, Bull. [IV.] 19/20. 2. pp. 59–68, Feb., 1916.)—The electrolytic method is not much used. To secure good deposits, the acidity should be constant and the kathodic current density uniform. The apparatus (*ibid.* 13. pp. 74–76, 1913] consists of a test-tube into which the anode, a Pt-Ir wire, enters through the glass from below, being surrounded by the cylindrical kathode of Pt gauze; part of the anode is sheathed with a fine glass tube, leaving the length parallel to the cylinder free. The kathode is coated with copper and mercury or mercury alone. The solution is obtained by dissolving 0·3 gm. of zinc in sulphuric and nitric acid, neutralising with ammonia, acidifying again with 0·25 cm.^{3} of sulphuric acid, and adding 0·2 gm. of sodium formate per dgm. of zinc. With currents of 4 or 5 amps./dm.^{2} the deposition takes 3 hours when the upper portion of the anode is sheathed, 2 hours when the lower. In the analysis of brass a solution is prepared in a similar way, but filtered to remove iron oxide. The zinc estimate comes out about 0·2 % too high on average. H. B.

1208. *Concentration of Electrolytes in the Neighbourhood of the Electrodes.* **S. Procopiu.** (Comptes Rendus, 164. pp. 725–727, May 7, 1917.)—In previous papers (compare *ibid.* 161. p. 492, 1915) the author has shown that when an electrode dips into an electrolyte at rest, in addition to the electrical double-layer on the electrode there is also another layer of different concentration from that of the mass of liquid. In the present paper it is deduced that the thickness (x_1) of this layer is given by the expression $x_1 = x_0 l^{k\nu/V}$, where x_0 is the thickness of the electrical double-layer, k the dielectric constant of the solvent, ν the e.m.f. produced by the movement of the electrode in the electrolyte (for example: two zinc electrodes dipping into a solution of zinc sulphate; the movement of the one electrode gives the e.m.f. ν), and V is the ordinary potential of the electrode. In the case of zinc electrodes and zinc sulphate solutions, x_1 is calculated to be of the order of 10^{-8} cm. T. S. P.

1209. *Hydration of Ions and Metal Overvoltage.* **E. Newbery.** (Chem. Soc., J. Trans. 111. pp. 470–489, June, 1917.)—Using apparatus similar to that described in previous papers [Abs. 179, 180 (1917)] the kathodic and anodic overvoltages of Cu, Ag, Zn, Cd, Tl, Pb, Sn, Fe, Ni, and Co have been measured during deposition of these metals from solutions of their salts, both in the absence and presence of colloids. The salts used were the sulphates, nitrates, and chlorides, whenever these salts were soluble. Current densities varying from 2 to 400 milliamps./cm.^{2} were used in each set of measurements. Kathodic overvoltages under these conditions are generally very low ($<$ 0·05 volt), but with iron, nickel, and cobalt they are very high ($>$ 0·2 and $<$ 1 volt). Anodic overvoltages are also low, unless passivity occurs; such passivity during metal deposition has been observed with Fe, Ni, and Tl. The cause of passivity has been discussed in previous papers. The single potentials of iron (− 0·04), nickel (0·31 − 0·34) and cobalt (0·15 — 0·22) have been re-determined and are different from those usually given. It is pointed out that accurate and reproducible values are obtained only in the absence of free hydrogen and metallic hydrides; neglect of precautions to prevent the occurrence of these substances has vitiated former measurements. When electrodes of these three metals are put in rapid motion with respect to the electrolyte, their potentials are changed by + 0·06 to + 0·18 volt; those of other metals are affected to a much smaller degree by similar treatment. An explanation of this phenomenon is given in terms of the hydration theory. Hydrated ions may be discharged at an electrode, but the electrode throws out only dehydrated ions, which move away with considerable velocity. They then hydrate, and return slowly, thus producing an appreciable fall of potential on the electrode. If, however, the electrode is in rapid motion the relative velocity of the hydrated ions on to the surface is increased, whilst the rate of discharge is almost unchanged, thus bringing about an alteration in the potential of the electrode. An observation of the rise of single potential of a metal on stirring the electrolyte thus gives a rough-and-ready method for determining the state of hydration of metallic ions. These and other considerations lead the author to conclude that the ions $\mathrm{H}^{\cdot}$, OH', $\mathrm{Fe}^{\cdot\cdot}$, $\mathrm{Ni}^{\cdot\cdot}$, and $\mathrm{Co}^{\cdot\cdot}$ are hydrated in aqueous solution, whilst the ions $\mathrm{Cu}^{\cdot\cdot}$, $\mathrm{Ag}^{\cdot}$, $\mathrm{Zn}^{\cdot\cdot}$, $\mathrm{Cd}^{\cdot\cdot}$, $\mathrm{Hg}^{\cdot}$, $\mathrm{Tl}^{\cdot}$, $\mathrm{Pb}^{\cdot\cdot}$, $\mathrm{Sn}^{\cdot\cdot}$, $\mathrm{NH_4}^{\cdot}$, $\mathrm{Na}^{\cdot}$, $\mathrm{K}^{\cdot}$, Cl', $\mathrm{NO_3}'$, and $\mathrm{SO_4}''$ are non-hydrated. Colloids are carried into a metal surface only by hydrated ions, and have no effect on overvoltage and little or none on the nature of the deposited metal unless such ions take part in carrying the current. Previous determinations of the degree of hydration of ions by observations of the change of concentration of a non-electrolyte present are considered to have given incorrect values owing to the transport of the non-electrolyte by the ions, and also owing to the action of electrical endosmosis. T. S. P.

1210. *Use of the Platinised Anode of Glass in the Electrolytic Estimation of Manganese.* **F. A. Gooch** and **M. Kobayashi**. (Am. J. Sci. 44. pp. 53–56, July, 1917.)—The estimation of manganese by electrolytic deposition as the dioxide upon the very small rotating anode previously described [see Abs. 880 (1917)] does not give good results, since the formation of permanganic acid takes place at the anode, owing to the high current density. When, however, a rotating anode of platinised glass, area 25 cm.^{2}, is used, the electrolytic estimation can be carried out with accurate results. The hydrated manganese dioxide deposited is dissolved in a mixture of sulphuric and sulphurous acid, the solution evaporated to dryness, and the Mn weighed as the anhydrous sulphate. The electrolyte used consisted of a solution of manganese sulphate acidified with acetic acid, to which was added either chrome alum or alcohol to prevent the formation of permanganic acid; in some cases ammonium sulphate was also added. T. S. P.